McDonnell Douglas Corporation
Douglas Aircraft Company

Feasibility Study Report

Soil and Groundwater Remediation at the Torrance (C6) Facility

November 1992

JMM

January 27, 1993

Douglas Aircraft Company
McDonnell Douglas Corporation
3855 Lakewood Blvd., Mail Stop 74-41
Long Beach, CA 90846

Attention: Scott Lattimore

Subject: Torrance (C6) Feasibility Study Report

Dear Scott:

Per your FAX dated January 26, 1993, enclosed please find 3 copies of each revised page for the Torrance (C6) feasibility study report. These revisions are briefly described below:

1. Figure 2-2 has been revised for the estimated extent of hydrocarbons at various depths. The scale on the figure has been checked against the existing documents.

2. Page 2-3, paragraph 2, line 3 has been changed from " ...and 1,1,1-trichloroethylene (TCE)." to read "... and trichloroethylene (TCE)."

3. Tables 2-3 through 2-11 have been revised for the distance of borings and tank locations from Tank 15T.

Should you have any further questions, please contact Majid Rasouli or me at your convenience.

Very truly yours,

JAMES M. MONTGOMERY,
CONSULTING ENGINEERS, INC.

Vivek Agrawal
Engineer

cc: Rick Lewis
Majid Rasouli
Ning-Wu Chang
File: 1220.0091/3.1.1

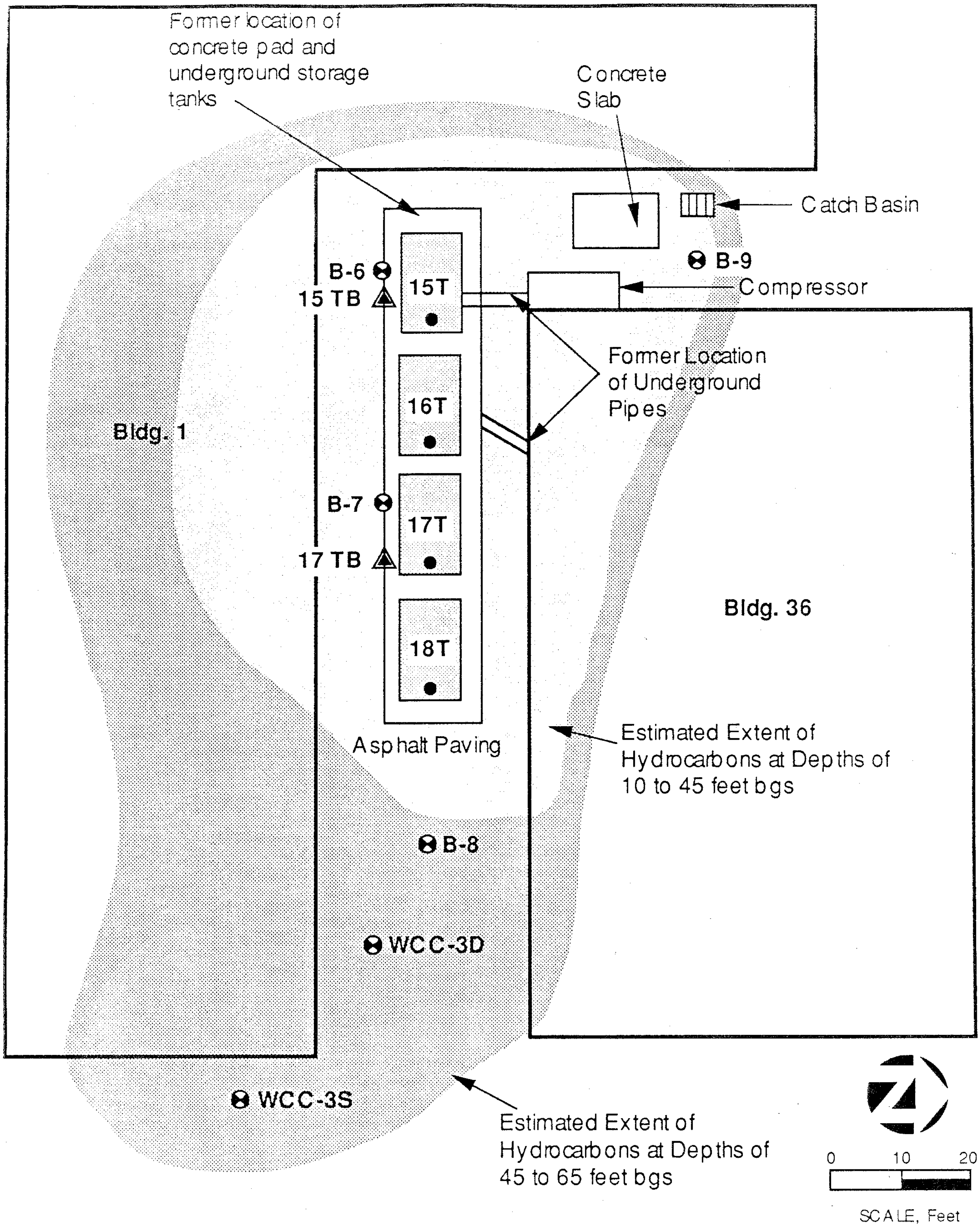

Figure 2-2
Estimated Extent of Hydrocarbons in the Unsaturated Soils

cluster. For the purpose of developing and costing alternatives, the lateral extent of hydrocarbons in soils was estimated as shown in Figures 2-2 and 2-3. Please note that DAC is contracting to futher define the extent of the hydrocarbon plume.

In general the solvents found in the soils at the site consist of three classes of organic compounds: aromatics, chlorinated hydrocarbons, and ketones. The most prevalent hydrocarbons are toluene, xylenes, 1,1,1-trichloroethane (TCA) and trichloroethylene (TCE). Earlier investigations indicate that TCE is probably present from an up-gradient source. Table 2-2 presents a summary of the various hydrocarbons detected and their corresponding frequency of detection and range of concentrations. Tables 2-3 through 2-11 illustrate the distribution of the major hydrocarbons in the soils near the tank cluster.

Groundwater

As part of the Phase I, II and III investigations conducted by WCC, twelve (12) shallow wells and two (2) deep wells were installed at the Torrance facility. Groundwater samples collected from these wells during this study (November 1991) indicate the presence of several hydrocarbons as shown in Table 2-12. All the laboratory reports and the chain-of-custody records are included in Appendix B. Although the list of hydrocarbons detected in the groundwater varies slightly from the list of hydrocarbons detected in the soil, the same three classes of compounds were present -- aromatics, chlorinated hydrocarbons, and ketones. Differences in the compounds detected can probably be attributed to variations in their degradability and the resultant breakdown products.

As expected, the major hydrocarbons detected in the groundwater are the same as those detected in the soil -- toluene, trichloroethylene (TCE), TCA, and 1,1-dichloroethylene (DCE). Groundwater samples also indicated the presence of methyl ethyl ketone (MEK) and methyl isobutyl ketone (MIBK) in two wells -- WCC-3S and WCC-6S.

As shown in Table 2-12, the largest concentrations of hydrocarbons were detected in Well WCC-3S which is located near the suspected source. This is consistent with the results reported by WCC for previous sampling events during the Phase I, II and III investigations at the site (Appendix A). However, the concentrations detected in Well WCC-6S are significantly higher than those detected in the previous sampling event (October, 1989). This increase indicates that the plume is migrating to the south at an estimated rate of about 100 feet per year. A significant increase in hydrocarbon concentration was also noted in samples from Wells WCC-4S, WCC-2S and WCC-8S. The increased levels in the latter two wells may indicate dispersion/diffusion in the upgradient and cross-gradient directions. Upgradient TCE presence has been identified and may be contributing to the increased levels, particularly with respect to Well WCC-2S.

At present no data are available to determine the full extent of the plume to the south and southwest. In general, the wells located on the eastern property boundary contain relatively low levels of hydrocarbons and are consistent with the levels detected during the previous sampling event.

Samples collected from the two deep wells (WCC-1D and WCC-3D) contained slightly higher levels of certain hydrocarbons (compared to results from the previous sampling

TABLE 2-1

TOTAL ORGANIC COMPOUND CONCENTRATIONS VERSUS DEPTH

	Boring Identification						
	B-9	**B-6**	**15TB**	**B-7**	**17TB**	**B-8**	**WCC-3D**
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Total Organic Compound Concentration (mg/kg)						
Depth (ft bgs)							
0							
10		0.15	<1				
15			1,568		<1		
20		2,398	9,712		<1		
25							
30		69		2	1,650		
35				1			
40	0.23	426		51			
45						0.27	
50	0.13	1		984		0.04	
55	0.09						0.8
60		21		80,190		1.5	
65						25	0.32
75							

Footnote:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits are not available for soil analysis.
3. Concentration values represent sum of all organic compounds detected in the boring at indicated depth..

TABLE 2-3

TOLUENE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WCC-3D
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10		0.064	<1				
15			870		<1		
20		1,900	6,300		<1		
25							
30		48		2			
35							
40	0.1	320		40			
45						0.27	
50	0.11	0.31		41		0.04	
55	0.06						0.59
60		10		450		1	
65						25	0.008
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

TABLE 2-4

TOTAL XYLENES CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	**B-6**	**15TB**	**B-7**	**17TB**	**B-8**	**WCC-3D**
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10		0.009	<1				
15			460				
20		390	1,300				
25							
30		21		0.09			
35				1			
40		21		1			
45							
50		0.03		2			
55							
60		3					
65							
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

TABLE 2-5

ETHYLBENZENE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WCC-3D
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10		0.001	<1				
15			41				
20		51	180				
25							
30							
35							
40		3					
45							
50							
55							
60							
65							
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

TABLE 2-6

1,1,1-TRICHLOROETHANE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WCC-3D
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10			<1		<1		
15			27				
20		12	38		<1		
25							
30				0.15			
35							
40	0.02	59		10			
45							
50		1		880			
55	0.03						0.07
60		8		59,000		0.44	
65						0.05	
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

TABLE 2-7

TRICHLOROETHYLENE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WCC-3D
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10		0.016					
15			10				
20		45	94				
25							
30				0.09			
35							
40	0.08	23					
45							
50	0.02	0.35					
55							
60							
65							
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

TABLE 2-8

1,1-DICHLOROETHYLENE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WCC-3D
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10			<1				
15							
20							
25							
30							
35							
40							
45							
50		0.06		57			
55							0.053
60				600			
65							
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

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TABLE 2-9

1,1-DICHLOROETHANE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	**B-6**	**15TB**	**B-7**	**17TB**	**B-8**	**WCC-3D**
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10		0.011					
15							
20							
25							
30							
35							
40	0.03						
45							
50		0.09					
55							0.098
60						0.04	
65							
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

TABLE 2-10

METHYLENE CHLORIDE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WCC-3D
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10		0.053					
15							
20							
25							
30							
35							
40							
45							
50							
55							
60				20,000			
65							
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

TABLE 2-11

KETONE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WCC-3D
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10							
15			160				
20			1,800				
25							
30					1,650		
35							
40							
45							
50							
55							
60							
65							0.31
75							

Footnotes:

1. Data include results for MIBK and MEK.
2. Blank cell indicates compound analyzed but not detected.
3. Detection limits for soil analysis are not available.

BOE-C6-0060886

FEASIBILITY STUDY REPORT

for

SOIL AND GROUNDWATER REMEDIATION
TORRANCE (C6) FACILITY

DOUGLAS AIRCRAFT COMPANY
3855 Lakewood Boulevard
Long Beach, California

Prepared for

McDONNELL DOUGLAS CORPORATION
DOUGLAS AIRCRAFT COMPANY
Long Beach, California

Prepared by

JAMES M. MONTGOMERY,
CONSULTING ENGINEERS, INC.
301 North Lake Avenue
Pasadena, California 91101

November 1992

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LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

Acronym	Description
A/W	air/water ratio
AOP	advanced oxidation process
API	American Petroleum Institute
ARAR	applicable or relevant and appropriate requirements
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, xylene
BTGA	best technology generally available
BTU	British Thermal Unit
CDWR	California Department of Water Resources
cm	centimeter
CO	carbon monoxide
COD	chemical oxygen demand
CSDLAC	County Sanitation District of Los Angeles County
DAC	Douglas Aircraft Company
DCA	1,1-dichloroethane
DCE	1,1-dichloroethylene
F	degree fahrenheit
FS	feasibility study
ft	feet
ft^2	square feet
GAC	granular activated carbon
gpd	gallons per day
gpm	gallons per minute
GW	groundwater
Hp	horsepower
in	inch
JMM	James M. Montgomery, Consulting Engineers, Inc.

ACRONYMS AND ABBREVIATIONS (Continued)

Acronym	Description
K_{oc}	soil partition coefficient
K_{ow}	octanol/water partition coefficient
Kg	kilogram
kw-h	kilowatt-hour
LACSD	Los Angeles County Sanitation District
lb	pound
m	meta
M	million
MCL	maximum contamination level
MEK	methyl ethyl ketone
mg/kg	milligram per kilogram
mg/l	milligrams per liter
MIBK	methyl isobutyl ketone
MW	monitoring well
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOx	Nitrogen oxide compounds
NPDES	National Pollution Discharge Elimination System
NSPC	New Source Performance Standards
o	ortho
OVA	overhead vapor analysis
p	para
PACT	powdered activated carbon technology
PM_{10}	particulate matter
POTW	Publicly Owned Treatment Works
ppm	parts per million
PVC	poly vinyl chloride
RBC	rotating biological contactor
RCRA	resource conservation and recovery act
RWQCB	Regional Water Quality Control Board

ACRONYMS AND ABBREVIATIONS (Continued)

Acronym	Description
SCAQMD	South Coast Air Quality Management District
scfm	standard cubic feet per minute
sec	second
SOx	sulphur oxide compounds
SVE	soil-vapor extraction
TCA	1,1,1-trichloroethane
TCE	trichloroethylene
TDS	total dissolved solids
TOC	total organic carbon
TTO	total toxic organics
USEPA	United States Environmental Protection Agency
UV	ultraviolet
VOC	volatile organic carbon
WCC	Woodward-Clyde Consultants
yr	year
µg/l	microgram per liter

BOE-C6-0060895

Chapter 1

BOE-C6-0060896

CHAPTER 1

INTRODUCTION

PURPOSE AND SCOPE

The purpose of this feasibility study (FS) is to identify and evaluate alternatives for remediation of hydrocarbons in soil and groundwater at Douglas Aircraft Company's (DAC) Torrance (C6) facility. The project scope is limited to developing remedial alternatives for soil bound hydrocarbons found near the cluster of the former solvent storage tanks (Tanks 15T, 16T, 17T and 18T) and for hydrocarbons in groundwater resulting from this suspected source.

Additional groundwater samples were collected and analyzed as part of this work, and these results, together with information presented in reports prepared by Woodward-Clyde Consultants (WCC), form the basis for selection of remedial alternatives.

PROJECT BACKGROUND

Facility Description

DAC Torrance (C6) facility manufactures components for various aircraft including the MD-11, MD-80 and C-17. The facility is located in an industrialized area of the City of Los Angeles which lies within the limits of Los Angeles County as shown in Figure 1-1. The project site is shown on Figure 1-2 and includes the area between and possibly under Buildings 1 and 36, and the effected water-bearing formation underneath the site and downgradient.

Activities in Building 1 involve metal finishing operations and machining of aluminum, steel and titanium. Building 36 is used for storage of various paints and solvents. Tanks 15T through 18T were used as underground bulk storage containers for solvents used in degreasing operations throughout the facility. All four solvent tanks were removed in October 1991 as part of the underground storage tank removal program.

Project History

As part of DAC's underground storage tank compliance program, soil boring(s) were placed in the vicinity of two diesel fuel tanks (Tanks 19T and 20T), and groundwater samples were collected from an existing, downgradient observation well (MW-1, later called WCC-1). Analytical results from soil samples collected near these tanks indicated elevated levels of petroleum hydrocarbons, but the groundwater samples indicated the presence of chlorinated hydrocarbons. Since the tanks did not contain chlorinated hydrocarbons, DAC contracted WCC to conduct two additional phases of investigation.

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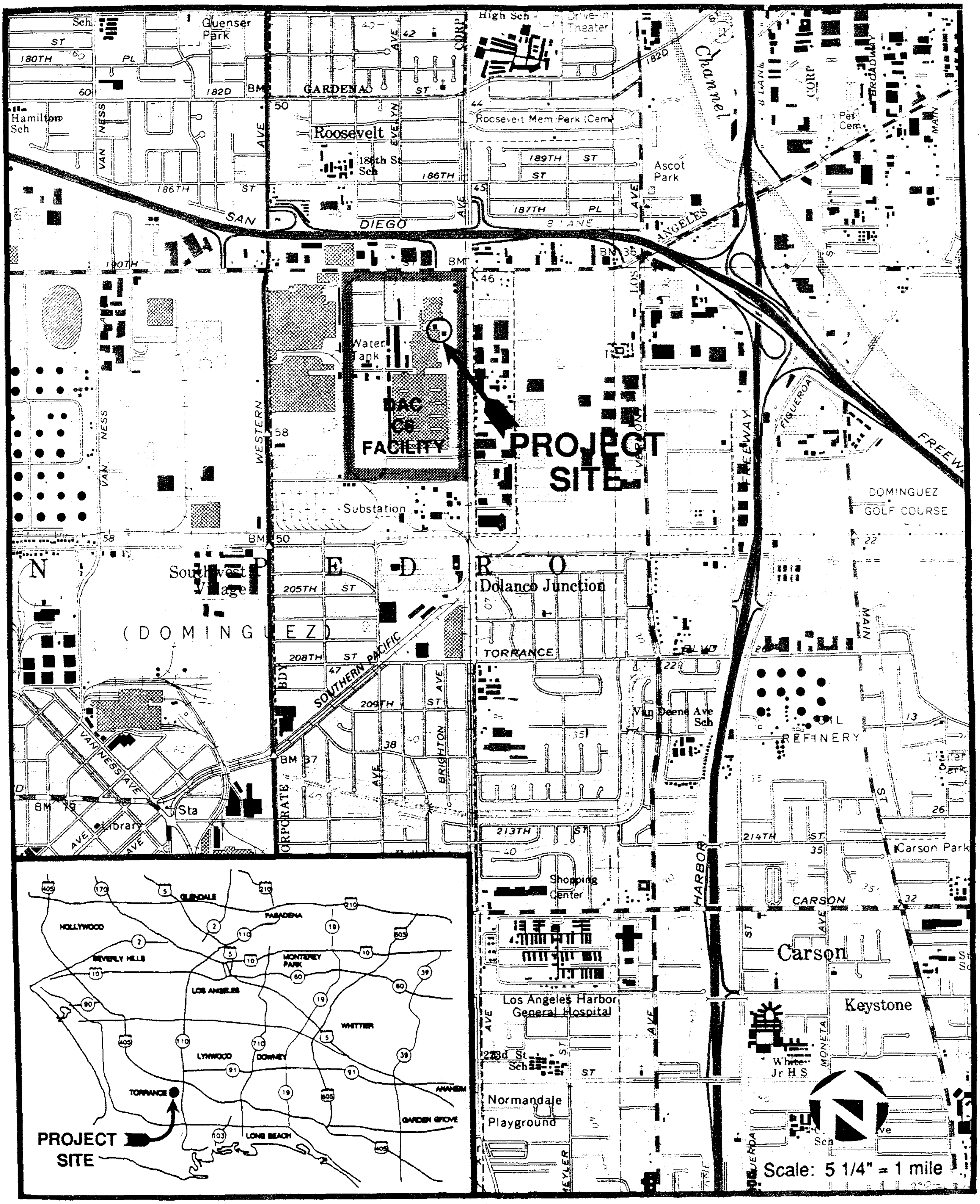

LOCATION MAP
FIGURE 1-1

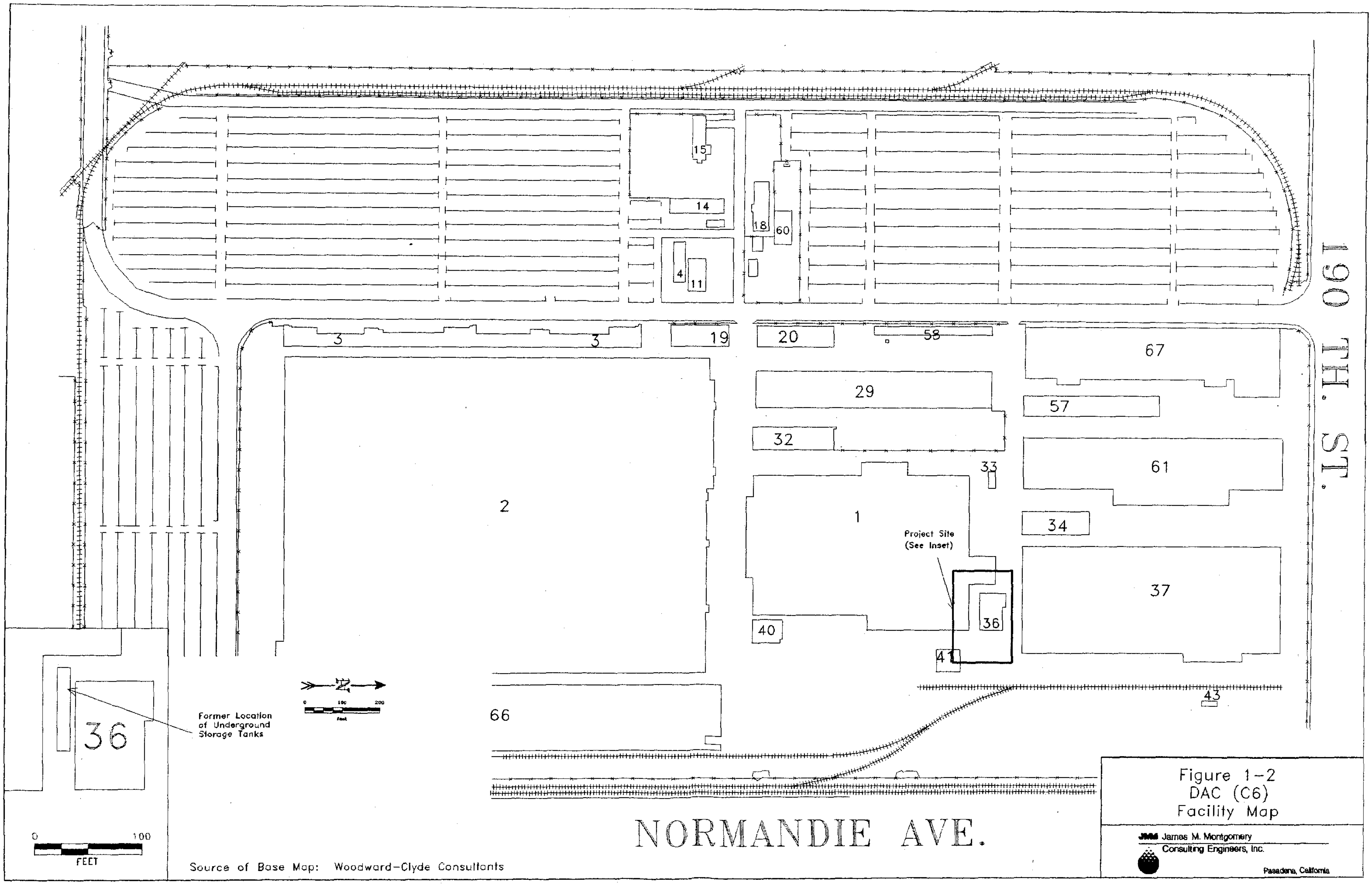

Figure 1-2
DAC (C6)
Facility Map

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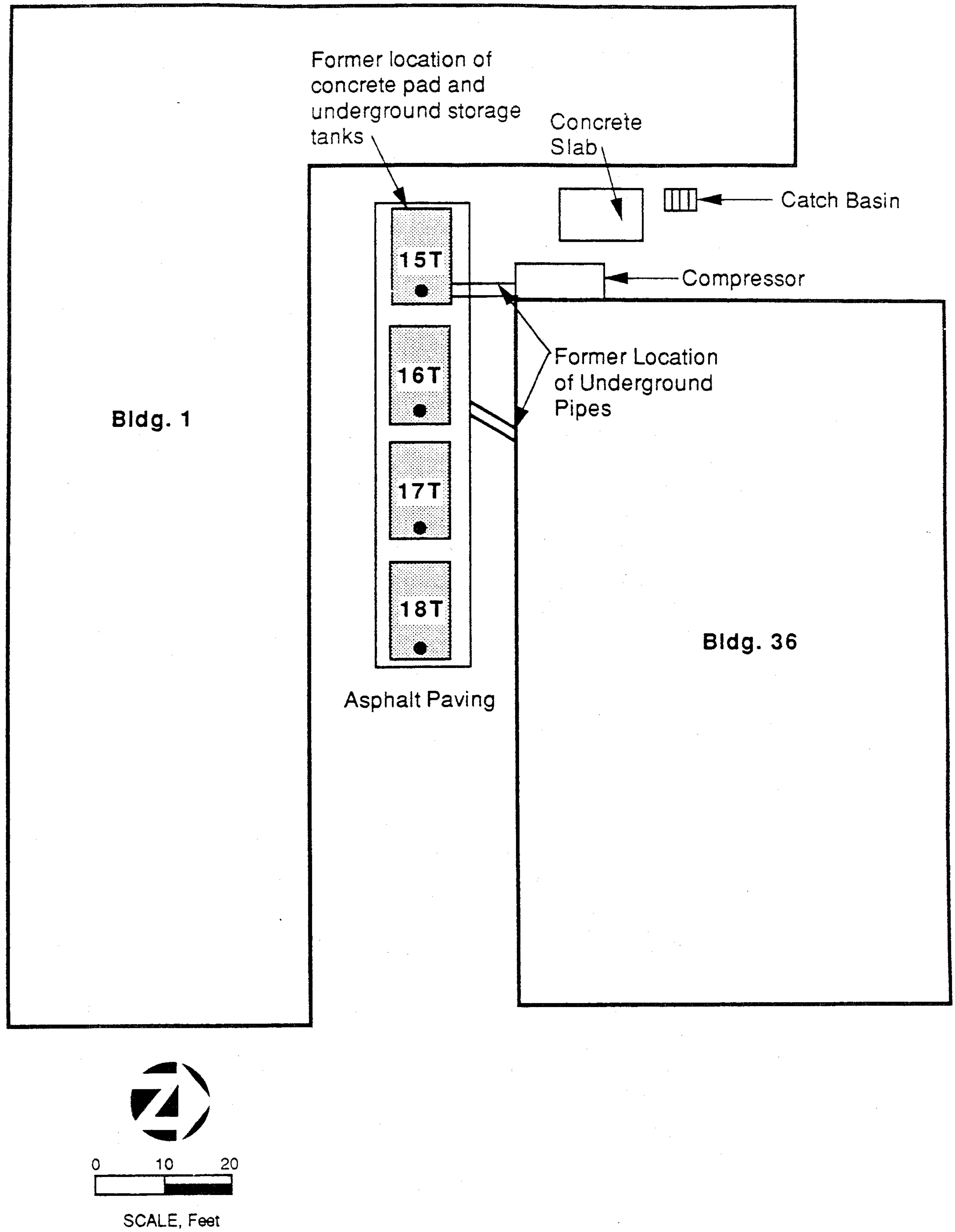

Figure 1-3
Former Location of
Solvent Storage Tanks

The results of these field investigations are presented in the following reports:

Final Report on Phase II of the Subsurface Investigation at Tanks 19T and 20T at the C6 Facility, Woodward-Clyde Consultants, May 1988.

Douglas Aircraft Company Torrance (C6) Facility--Preliminary Phase III Groundwater and Soil Investigation Report, Woodward-Clyde Consultants, March 1990.

James M. Montgomery, Consulting Engineers, Inc. (JMM) was subsequently retained by DAC to develop and design a remediation system for cleanup of hydrocarbons in soil and groundwater in the vicinity of the solvent tanks.

Site Geology

The Torrance facility is located in the Southwestern Block of the Los Angeles basin (Yerkes et al., 1965). The Southwestern Block is bounded on the northeast by a series of low hills denoting the Newport-Inglewood structural zone and on the southwest by the Palos Verdes Hills. The site is underlain by marine and continental deposits of the Upper Pleistocene Lakewood Formation, which is approximately 200 feet thick in the site vicinity (CDWR, 1961).

Soil types encountered while drilling to depths between 30 and 90 feet below grade across the site consist predominantly of silty clay in the upper 40 to 50 feet with interbedded silty fine-grained sand, silt and clay below. Two borings drilled to 140 feet below grade (for monitoring wells WCC-1D and 3D shown in Figure 1-4) indicate that the same types of deposits are present in this interval, with interbeds of medium-grained sand. The sand, silt and clay deposits are complexly interbedded and laterally discontinuous. Shell fragments indicative of marine deposits were observed in many borings at depths of approximately 55 feet below grade and lower. Soils types at the site are typical of continental floodplain and overbank deposition adjacent to a near-shore marine environment with fluctuating sea levels.

Site Hydrogeology

In the site vicinity, the Lakewood Formation consists of two members, the surfacial Bellflower aquiclude and the underlying Gage aquifer. The Bellflower aquiclude, as identified by CDWR (1961), "comprises all of the fine-grained sediments that extend from the ground surface, or from the base of the semi-perched aquifer, down to the first aquifer below." Near-surface coarse sand and gravel deposits which typify the semi-perched aquifer (sometimes found above the Bellflower aquiclude) were not identified in boring logs from previous site investigations. Regional hydrogeologic data indicate that the base of the Bellflower aquiclude is approximately 150 feet below grade and that the underlying Gage aquifer is approximately 40 feet thick (CDWR, 1961).

Groundwater was encountered at approximately 75 feet below grade during the initial stages of site characterization in 1986 and 1987; groundwater levels measured during 1989 were approximately 5 feet higher at 70 feet below grade. Groundwater measurements

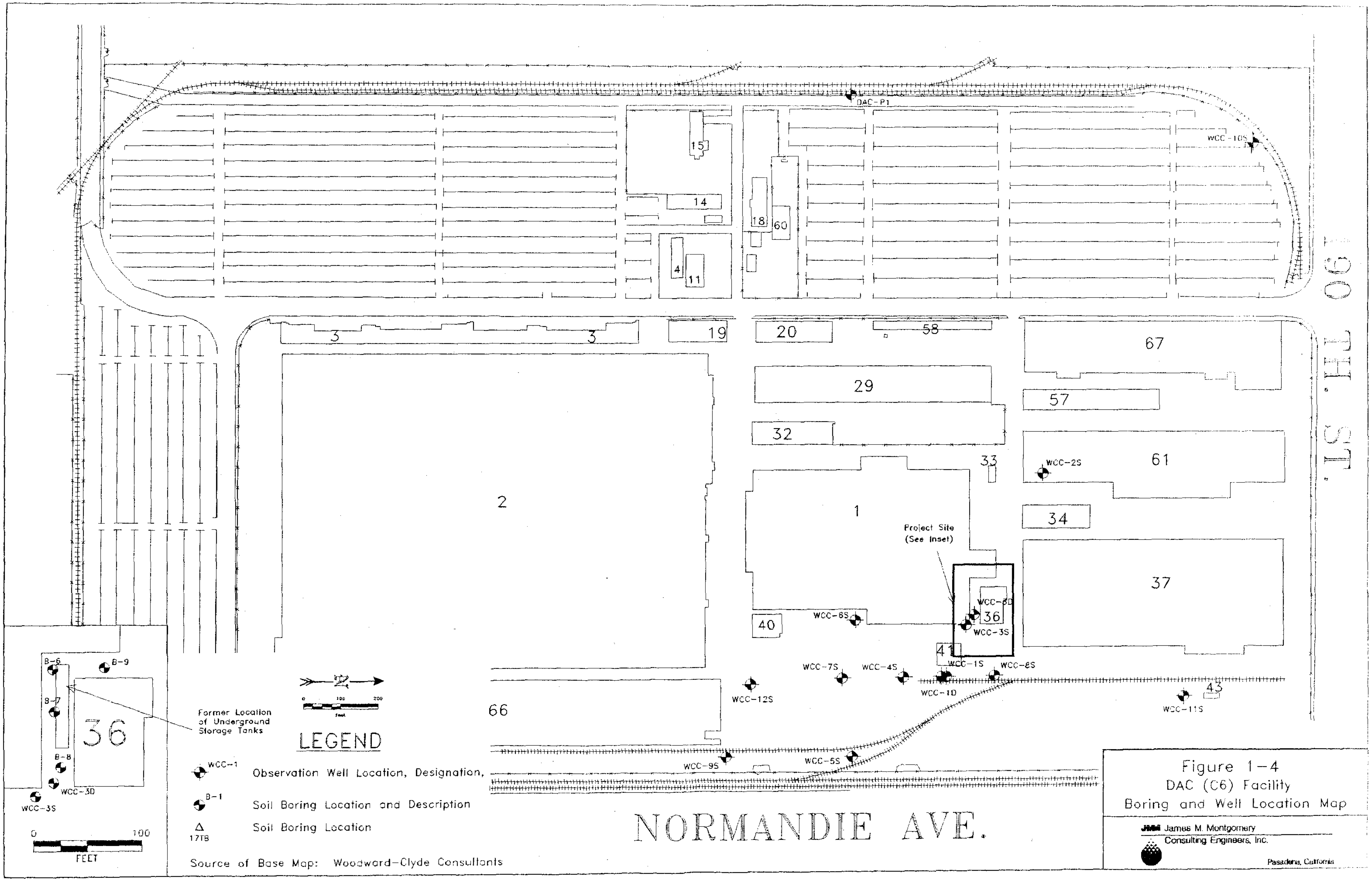

Figure 1-4
DAC (C6) Facility
Boring and Well Location Map

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obtained in November 1991 indicate that the groundwater surface is still about 70 feet below grade (roughly 19 feet below Mean Sea Level).

The groundwater encountered beneath the site is unconfined with a local hydraulic gradient of 0.002 feet/foot to the south. Based on the results of a pump test conducted by WCC and water level measurements, the horizontal hydraulic conductivity appears to predominate over the vertical hydraulic conductivity, which is typical of layered sedimentary deposits. Of the eight observation wells monitored during the pump test, all but two (WCC-9S and WCC-1D) showed some response to the pump test. One of these, WCC-9S, was located 500 feet to the south-southeast of the pumped well (WCC-4S) and the other, WCC-1D, was screened between 120 and 140 feet below grade versus the screened intervals between approximately 60 and 90 feet below grade in the pumped well.

Hydraulic conductivities calculated from the pump test were approximately 500 gpd/ft^2 (2.36×10^{-2} cm/sec) in three wells (the pumped well plus two wells to the north) and approximately 1000 gpd/ft^2 (4.72×10^{-2} cm/sec) in two wells to the south and southwest of the pumped well. These data indicate that the interbedded sediments possess horizontal anisotropy as well as vertical anisotropy. For the purposes of the feasibility study, an average hydraulic conductivity of 700 gpd/ft^2 (3.30×10^{-2} cm/sec) was assumed. Based on this value, the groundwater velocity in this portion of the aquifer is approximately 0.62 feet/day or 226 feet/year.

Given that a pumping rate of 13 gpm was able to be sustained in well WCC-4S over the course of the 30 hour constant discharge test, it was assumed (for the purpose of this feasibility study) that a flow rate of 10 gpm could be sustained in each of the wells at the site. The actual achievable pumping rate, however, is highly dependent on the condition of the well, the installation of the well, and the screened interval. Additional pump tests should be conducted to confirm the sustainable flow from any of the wells which will be pumped for remediation purposes.

Chapter 2

CHAPTER 2

ASSESSMENT OF SOLVENTS

NATURE AND EXTENT OF SOLVENTS

Using the recent groundwater data collected by JMM and the results of the three previous field investigations, an assessment of the nature and extent of hydrocarbons associated with the cluster of solvent storage tanks was conducted. The following text discusses the extent of hydrocarbons in the surface soils (0-10 feet bgs), subsurface soils (10 to 75 feet bgs) and groundwater. Figure 2-1 shows the location of soil borings and wells installed in the immediate vicinity of the former solvent storage tanks.

Surface Soils

Based on the analytical results of soil samples and OVA readings reported on the boring logs, there does not appear to be any solvent in the soil at depths from zero to 10 feet below ground surface.

Subsurface Soils

Data from soil samples collected at a depth of 10 feet below grade indicate the presence of low levels (<1 mg/kg total) of several hydrocarbons near Tank 15T which was reported by WCC as a potential source of volatile organic compounds (VOCs). OVA readings on the order of 600 to 1000 ppm above background were also noted in boring logs for this depth interval.

Soil samples taken at depths of 15 to 20 feet below grade in the area around Tank 15T contained higher levels of hydrocarbons. As shown in Table 2-1, the total hydrocarbon concentrations in this interval were in the range of 1,568 mg/kg to 9,712 mg/kg with the primary constituents being toluene and xylenes. Table 2-1 also illustrates that elevated organic concentrations were detected in soil samples at depths from 15 feet down to the groundwater. Most notably, the sample from B-7 contained 59,000 mg/kg of TCA and 20,000 mg/kg of methylene chloride.

In general, the concentration of total hydrocarbons decreases with increasing lateral distance from the tank cluster. Given the relatively high content of silty clays present in the shallow soils (10 to 45 feet bgs) at the site, it is unlikely that extensive lateral migration of the hydrocarbons has occurred in the shallow unsaturated zone. However, data from samples collected in the deep unsaturated soils (45 to 75 feet bgs) indicate that hydrocarbons may have migrated over a wider area, particularly in the capillary fringe zone (65-75 feet), which is the zone immediately above the water table where water is held up in the soil by capillary forces. This is not surprising given that the formation is more permeable in this interval and several of the hydrocarbons detected are lighter than water and are highly mobile. In general, however, the available data are insufficient to assess the full extent of the hydrocarbon plume, particularly to the south and west of the tank

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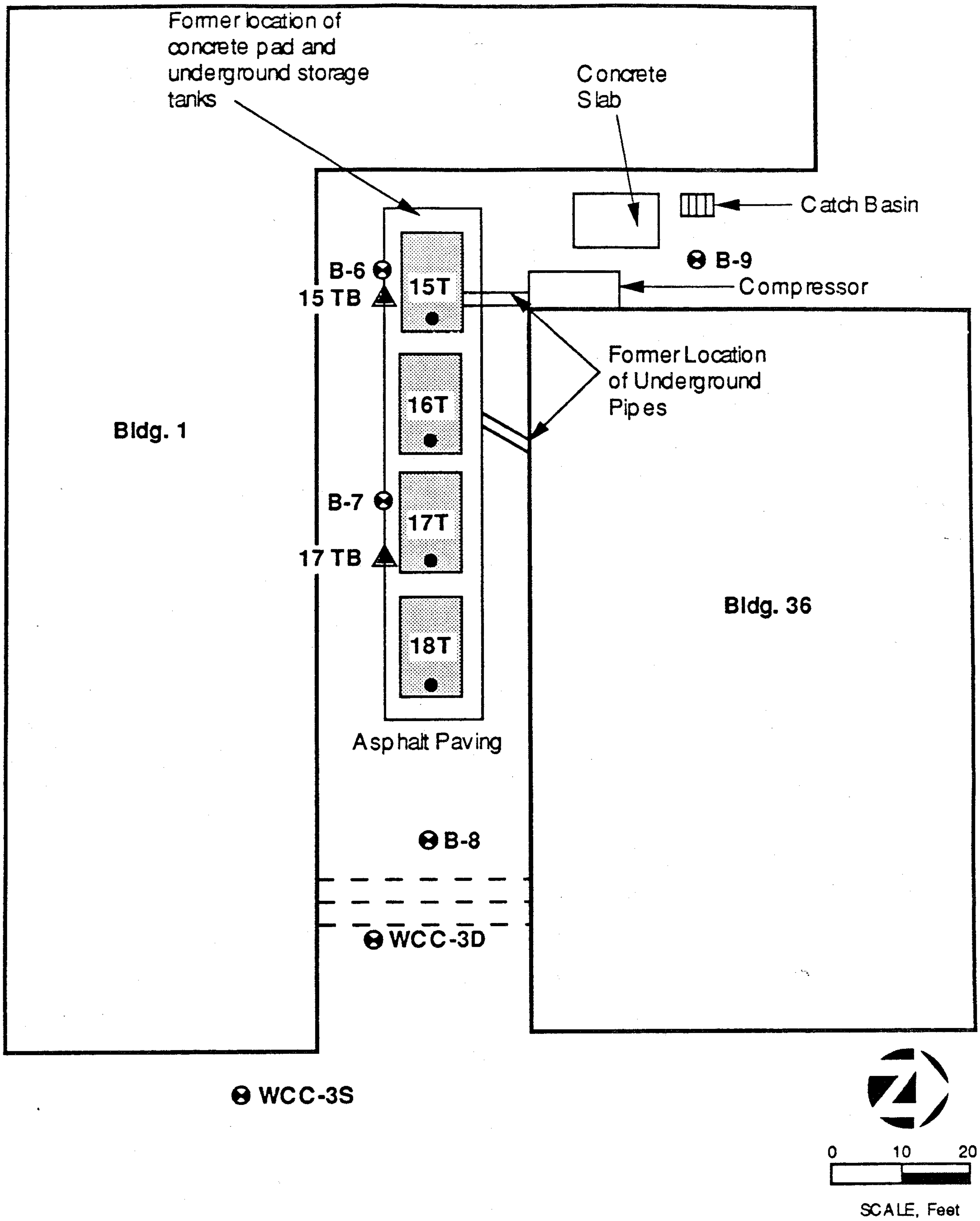

Figure 2-1
Soil Borings and Wells in the
Immediate Vicinity of the Former Tank Site

TABLE 2-1

TOTAL ORGANIC COMPOUND CONCENTRATIONS VERSUS DEPTH

	Boring Identification						
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55	0.09						0.8
60		21		80,190		1.5	
65						25	0.32
75							

Footnote:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits are not available for soil analysis.
3. Concentration values represent sum of all organic compounds detected in the boring at indicated depth..

BOE-C6-0060907

cluster. For the purpose of developing and costing alternatives, the lateral extent of hydrocarbons in soils was estimated as shown in Figures 2-2 and 2-3. Please note that DAC is contracting to futher define the extent of the hydrocarbon plume.

In general the solvents found in the soils at the site consist of three classes of organic compounds: aromatics, chlorinated hydrocarbons, and ketones. The most prevalent hydrocarbons are toluene, xylenes, 1,1,1-trichloroethane (TCA) and trichloroethylene (TCE). Earlier investigations indicate that TCE is probably present from an up-gradient source. Table 2-2 presents a summary of the various hydrocarbons detected and their corresponding frequency of detection and range of concentrations. Tables 2-3 through 2-11 illustrate the distribution of the major hydrocarbons in the soils near the tank cluster.

Groundwater

As part of the Phase I, II and III investigations conducted by WCC, twelve (12) shallow wells and two (2) deep wells were installed at the Torrance facility. Groundwater samples collected from these wells during this study (November 1991) indicate the presence of several hydrocarbons as shown in Table 2-12. All the laboratory reports and the chain-of-custody records are included in Appendix B. Although the list of hydrocarbons detected in the groundwater varies slightly from the list of hydrocarbons detected in the soil, the same three classes of compounds were present -- aromatics, chlorinated hydrocarbons, and ketones. Differences in the compounds detected can probably be attributed to variations in their degradability and the resultant breakdown products.

As expected, the major hydrocarbons detected in the groundwater are the same as those detected in the soil -- toluene, trichloroethylene (TCE), TCA, and 1,1-dichloroethylene (DCE). Groundwater samples also indicated the presence of methyl ethyl ketone (MEK) and methyl isobutyl ketone (MIBK) in two wells -- WCC-3S and WCC-6S.

As shown in Table 2-12, the largest concentrations of hydrocarbons were detected in Well WCC-3S which is located near the suspected source. This is consistent with the results reported by WCC for previous sampling events during the Phase I, II and III investigations at the site (Appendix A). However, the concentrations detected in Well WCC-6S are significantly higher than those detected in the previous sampling event (October, 1989). This increase indicates that the plume is migrating to the south at an estimated rate of about 100 feet per year. A significant increase in hydrocarbon concentration was also noted in samples from Wells WCC-4S, WCC-2S and WCC-8S. The increased levels in the latter two wells may indicate dispersion/diffusion in the upgradient and cross-gradient directions. Upgradient TCE presence has been identified and may be contributing to the increased levels, particularly with respect to Well WCC-2S.

At present no data are available to determine the full extent of the plume to the south and southwest. In general, the wells located on the eastern property boundary contain relatively low levels of hydrocarbons and are consistent with the levels detected during the previous sampling event.

Samples collected from the two deep wells (WCC-1D and WCC-3D) contained slightly higher levels of certain hydrocarbons (compared to results from the previous sampling

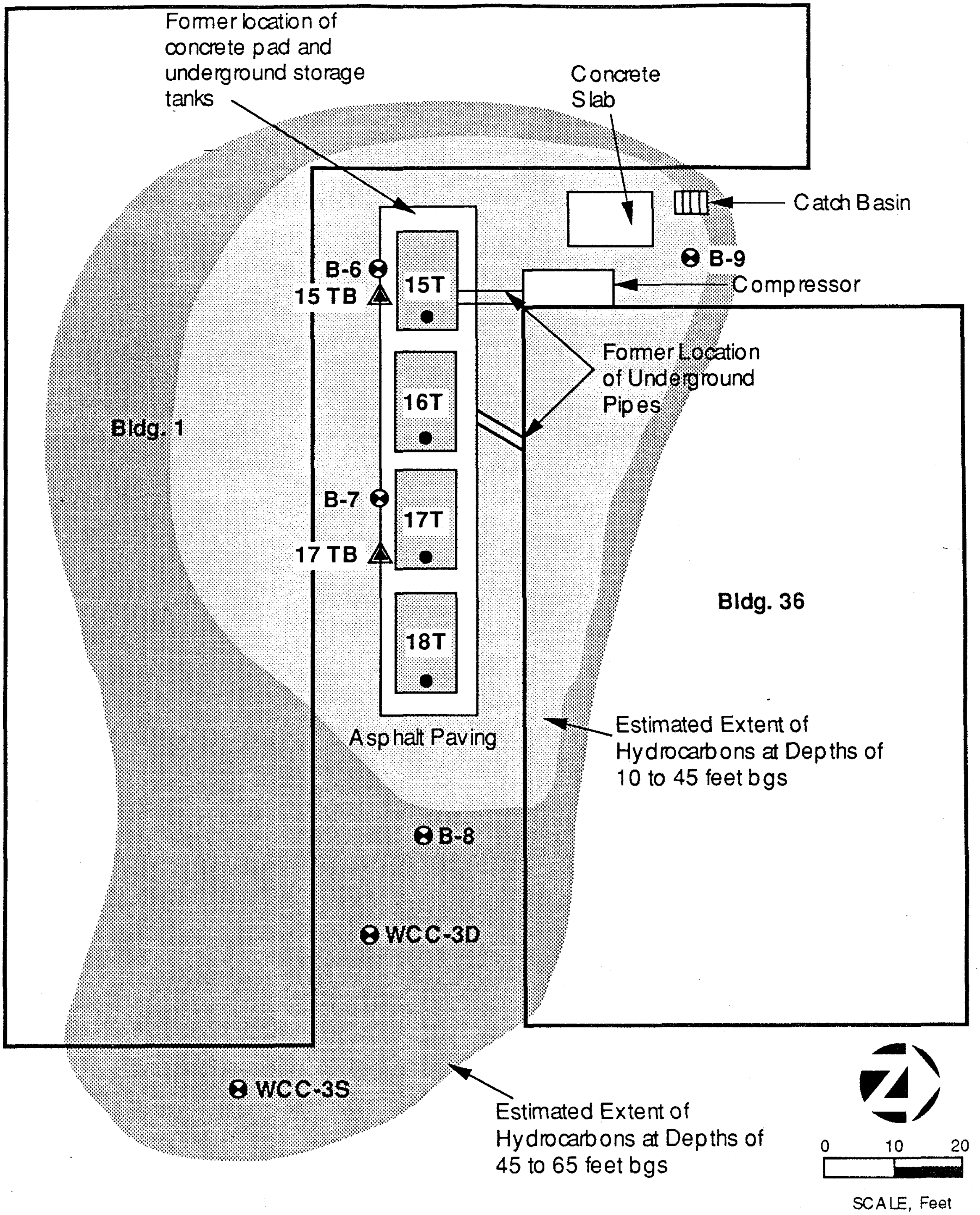

Figure 2-2
Estimated Extent of Hydrocarbons in the Unsaturated Soils

TABLE 2-9

1,1-DICHLOROETHANE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WC
Distance From Tank 15T (ft)	40	10	8	28	35	75	
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10		0.011					
15							
20							
25							
30							
35							
40	0.03						
45							
50		0.09					
55							(
60						0.04	
65							
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

TABLE 2-10

METHYLENE CHLORIDE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WCC-3D
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10		0.053					
15							
20							
25							
30							
35							
40							
45							
50							
55							
60				20.000			
65							
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

TABLE 2-11

KETONE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WCC-3D
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10							
15			160				
20			1,800				
25							
30					1,650		
35							
40							
45							
50							
55							
60							
65							0.31
75							

Footnotes:

1. Data include results for MIBK and MEK.
2. Blank cell indicates compound analyzed but not detected.
3. Detection limits for soil analysis are not available.

BOE-C6-0060912

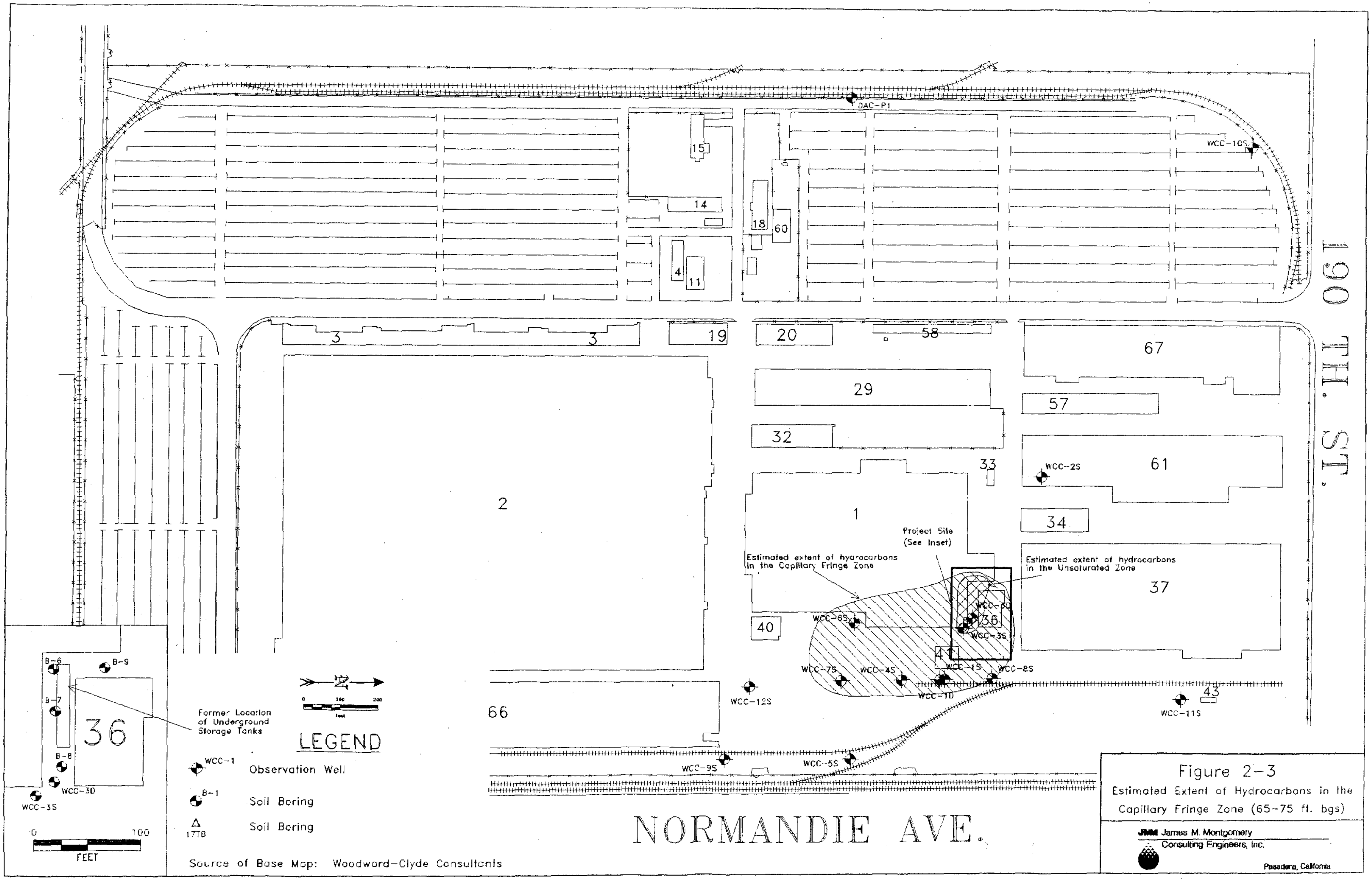

Figure 2-3
Estimated Extent of Hydrocarbons in the Capillary Fringe Zone (65-75 ft. bgs)

BOE-C6-0060913

TABLE 2-2

FREQUENCY OF DETECTION

Compound	Range of Concentrations (mg/kg)	Number of Detections	Frequency of Detection (%)
Aromatics			
Toluene	0.008 to 6,300	27	93
Total Xylenes	0.009 to 1,300	13	45
Ethylbenzene	0.001 to 180	6	21
Chlorinated Solvents			
1,1,1-Trichloroethane	0.02 to 59,000	18	62
Trichloroethylene	0.007 to 94	11	38
1,1-Dichloroethylene	0.05 to 600	6	21
1,1-Dichloroethane	0.01 to 0.098	5	17
Methylene Chloride	0.05 to 20,000	2	7
Tetrachloroethylene	140	1	3.5
Ketones			
Methyl ethyl ketone	0.55 to 1,800	6	21
Methyl isobutyl ketone	0.31 to 840	5	17

Note: Total number of samples was 29 which includes soil samples collected in the vicinity of the tank cluster (i. e. , B-6, B-7, B-8, B-9, 15TB, 17TB, and WCC-3S) and from well WCC-6S.

BOE-C6-0060914

TABLE 2-3

TOLUENE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WCC-3D
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10		0.064	<1				
15			870		<1		
20		1,900	6,300		<1		
25							
30		48		2			
35							
40	0.1	320		40			
45						0.27	
50	0.11	0.31		41		0.04	
55	0.06						0.59
60		10		450		1	
65						25	0.008
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

TABLE 2-4

TOTAL XYLENES CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WCC-3D
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10		0.009	<1				
15			460				
20		390	1,300				
25							
30		21		0.09			
35				1			
40		21		1			
45							
50		0.03		2			
55							
60		3					
65							
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

TABLE 2-5

ETHYLBENZENE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WCC-3D
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10		0.001	<1				
15			41				
20		51	180				
25							
30							
35							
40		3					
45							
50							
55							
60							
65							
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

TABLE 2-6

1,1,1-TRICHLOROETHANE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WCC-3D
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10			<1		<1		
15			27				
20		12	38		<1		
25							
30				0.15			
35							
40	0.02	59		10			
45							
50		1		880			
55	0.03						0.07
60		8		59,000		0.44	
65						0.05	
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

BOE-C6-0060918

TABLE 2-7

TRICHLOROETHYLENE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WCC-3D
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10		0.016					
15			10				
20		45	94				
25							
30				0.09			
35							
40	0.08	23					
45							
50	0.02	0.35					
55							
60							
65							
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

BOE-C6-0060919

TABLE 2-8

1,1-DICHLOROETHYLENE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WCC-3D
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10			<1				
15							
20							
25							
30							
35							
40							
45							
50		0.06		57			
55							0.053
60				600			
65							
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

BOE-C6-0060920

TABLE 2-9

1,1-DICHLOROETHANE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WCC-3D
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10		0.011					
15							
20							
25							
30							
35							
40	0.03						
45							
50		0.09					
55							0.098
60						0.04	
65							
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

BOE-C6-0060921

TABLE 2-10

METHYLENE CHLORIDE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	B-6	15TB	B-7	17TB	B-8	WCC-3D
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10		0.053					
15							
20							
25							
30							
35							
40							
45							
50							
55							
60				20,000			
65							
75							

Footnotes:

1. Blank cell indicates compound analyzed but not detected.
2. Detection limits for soil analysis are not available.

TABLE 2-11

KETONE CONCENTRATION VERSUS DEPTH

	Boring Identification						
	B-9	**B-6**	**15TB**	**B-7**	**17TB**	**B-8**	**WCC-3D**
Distance From Tank 15T (ft)	40	10	8	28	35	75	90
	Concentration (mg/kg)						
Depth (ft bgs)							
0							
10							
15			160				
20			1,800				
25							
30					1,650		
35							
40							
45							
50							
55							
60							
65							0.31
75							

Footnotes:

1. Data include results for MIBK and MEK.
2. Blank cell indicates compound analyzed but not detected.
3. Detection limits for soil analysis are not available.

TABLE 2-12

ANALYTICAL RESULTS FOR GROUNDWATER SAMPLES COLLECTED DURING NOVEMBER 1991
ORGANIC COMPOUNDS

(all results in μg/l)

WELL NO.	1,1-DCE	1,1-DCA	1,1,1-TCA	TCE	MIBK	Toluene	Benzene	cis, trans - 1,2-DCE	Methylene Chloride	MEK	Chloroform
WCC-1S	1,300			3,700					9.2 (B)		
WCC-2S	30		8	110		75			15 (B)		
WCC-3S	12,000	400 (J)	6,900	7,900	70,000	27,000		550 (J)	7.1 (B)	12,000	250 (J)
WCC-4S	1,000		20 (J)	2,200					10.7 (B)		
WCC-5S	20			8		7			15 (B)		
WCC-6S	5,800		5,000	3,000	17,000	35,000			8.6 (B)	21,000	
WCC-7S	390			1,200							
WCC-8S	2,600		400	3,000		120 (J)		40 (J)	13.4 (B)		25 (J)
WCC-9S				20					20 (B)		
WCC-10S				87							
WCC-11S	10			80					40 (B)		
WCC-12S	300		17 (J)	900					13.6 (B)		
WCC-1D	90		8	40		20			15 (B)		
WCC-3D	20		60								
Trip Blank 1									30		
Trip Blank 2				3					34		

Footnotes:
1. Only compounds which were detected under the recent sampling activity or were previously detected by WCC are shown in the table. For a complete list of compounds analyzed by JMM see Appendix A.
2. B = The presence of this compound is uncertain since it was detected in blank samples at similar or higher concentrations.
   J = This value is an estimate only since the compound was present at a concentration lower than the lowest standard.
3. Blank cell indicates compound was analyzed but not detected.

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event). Well WCC-1D, in particular, showed elevated levels of DCE, TCA, TCE and toluene.

The concentration of total organics detected in groundwater in each well at the site is shown in Figure 2-4.

Groundwater samples collected during the November 1991 sampling activity were also analyzed for general water quality parameters and certain inorganic compounds. Table 2-13 presents the results of the general water quality analysis. As expected, Well WCC-3S has an elevated chemical oxygen demand (COD) which is due to the presence of the hydrocarbons. Analytical results for specific inorganic constituents are shown in Appendix B. The only constituent of potential concern is aluminum which was detected at concentrations in the range of 1 to 3 mg/l. Although no data are available to determine the background or upgradient aluminum concentration, the levels detected at the site are above the state MCL of 1 mg/l.

Solvent Transport and Fate

The DAC (C6) Facility, located on the Torrance Plain of the Los Angeles Coastal Basin, is underlain by the Lakewood Formation. Borings at the site have encountered predominantly clays and silts to depths of 25 to 50 feet. The primary aquifers beneath the site are the "Semi-Perched" and the Gage. The upper portion of the semi-perched aquifer appears to consist of sands and silty sands with occasional, discontinuous interbeds of silt and clays; while the lower portion is composed of thinner beds of sand, silty sand and a minor amount of silt.

The rate of solvent transport or migration potential is based on several elements including depth to groundwater, percent silt and clay, relative volatility of hydrocarbons, and solubility of hydrocarbons in water. The depth to groundwater has been noted at approximately 75 feet bgs. Borings at the site have encountered predominantly clayey silts and silty sands. Solvents will migrate through sand and gravel to a greater extent than through silt and clay due to greater pore size and hydraulic conductivity. Therefore, the percent silt and clay observed at a site can be used as an indicator of migration potential.

The major organic compounds detected in soil and groundwater at the DAC (C6) site and their benchmark parameters are shown in Table 2-14. Three groups of substances have been identified: chlorinated hydrocarbons (methylene chloride, 1,1-DCE, TCA and TCE), aromatics (toluene, ethylbenzene and xylene) and ketones (MEK and MIBK). The parameters listed indicate mobility, persistence, and treatability of the chemical hydrocarbons.

Volatilization can be a significant process for transport and removal of hydrocarbons in the unsaturated zone. Volatilization depends on several site-specific factors, including soil porosity, moisture content, surface wind speed, temperature, and nature of the surface. Hydrocarbon properties describing the potential for volatilization are boiling point, vapor pressure, and Henry's constant. Volatilization cannot be expected to be a significant transport process at the Torrance site due to the fact that the site is covered with asphalt or concrete and the hydrocarbons are generally present in the deeper soils.

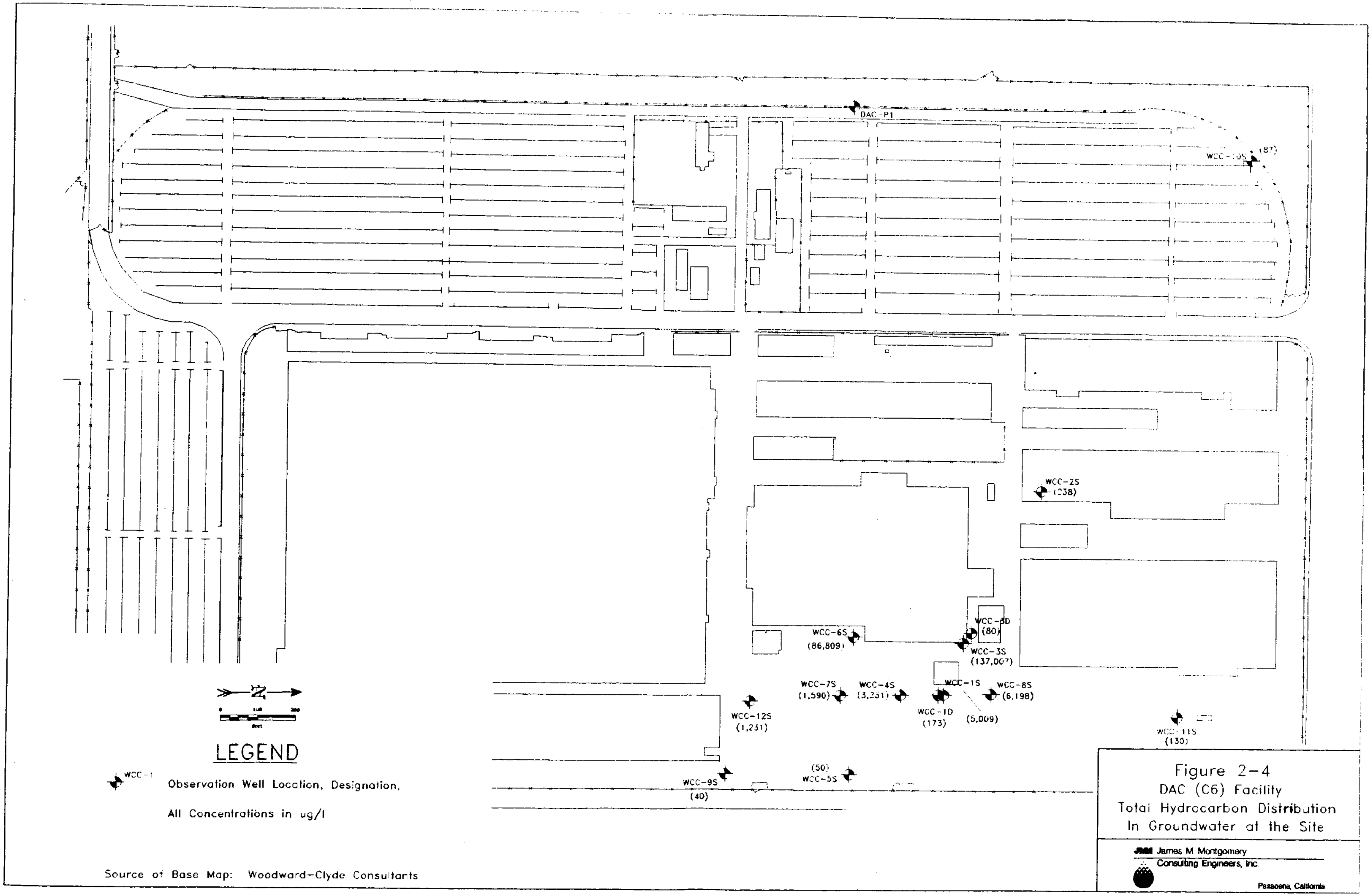

Figure 2-4
DAC (C6) Facility
Total Hydrocarbon Distribution
In Groundwater at the Site

BOE-C6-0060926

TABLE 2-13

ANALYTICAL RESULTS FOR GROUNDWATER SAMPLES COLLECTED DURING NOVEMBER 1991
GENERAL WATER QUALITY PARAMETERS

WELL NO.	TOC (mg/l)	COD (mg/l)	pH* (S.U.)	ALK (mg/l)	TDS (mg/l)	Hardness (mg/l)	EC* (umhos)
WCC-1S			7.6				1000
WCC-2S							
WCC-3S		290	7	325	820	446	1500
WCC-4S			7				950
WCC-5S			8.1				400
WCC-6S							
WCC-7S	0.7	56	6.9	120	650	303	860
WCC-8S			7				1100
WCC-9S	0.9	20	7				760
WCC-10S			8.3				1100
WCC-11S			7.2				1050
WCC-12S			6.9				980
WCC-1D	0.7	10	7.2	190	400	195	610
WCC-3D			7.6				590

Footnotes: If no data is shown, the sample was not analyzed for that constituent.
* = results from field analysis.

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TABLE 2-14

PHYSICAL AND CHEMICAL CHARACTERISTICS OF HYDROCARBONS

Chemical Compound Characteristics	1,1-DCE	1,1,1-TCA	TCE	Methylene Chloride	Toluene	Ethyl Benzene	Xylene (o)	Xylene (p)	Xylene (m)	1,1-DCA	MIBK	MEK
Boiling Point, (deg. C)	31.7	71	86.7	39.75	110.8	136.2	144.4	138.4	139	57.2	116	79.6
Molecular Weight	96.95	133.41	131.5	84.93	92.1	106.17	106.17	106.17	106.17	98.96	100.2	72.1
Log O/W Partition Coeff.	2.13	2.5	2.38	1.25	2.69	3.15	2.77	3.15	3.2	1.79	1.19	0.26
Water Solubility, mg/l at 20 C	2250	4400	1100	20000	515	152	175	198	130	5500	17000	353000
Vapor Pressure, mm hg at 20 C	500	100	60	349	22	7	5	6.5	6	180	6	77.5
Henry Law Constt., atm-m^3/mole	3.01E-02	1.44E-02	9.10E-03	2.68E-03	6.37E-03	6.43E-03	5.10E-03	7.68E-03	7.68E-03	4.60E-03	9.40E-05	2.74E-05
Specific Gravity, gm/cm^3	1.218	1.35	1.46	na	0.867	0.867	0.88	0.8611	0.8642	1.174	0.8017	0.805
Soil Partition Coefficient, Koc, l/kg	65	152	126	8.8	300	1100	240	240	240	na	na	4.5
Carbon Adsorption Capacity, mg/gm	4.9	2.5	28	1.3	26	53	85	85	85	1.8	6.2	0.24
Biodegradability, BOD/COD	Poor	Poor	Poor	Poor	Fair	Fair	Fair	Fair	Fair	Poor	Fair	Good

na = not available

BOE-C6-0060928

Hydrophobic organic chemicals dissolved in water will tend to adsorb onto solid phases that come in contact with the water. The large solid surface area available in soils allows for a substantial mass of hydrocarbons to be adsorbed. It has been demonstrated that the octanol/water partition coefficient (K_{ow}) and the soil partition coefficient (K_{oc}) can be used to estimate the relative affinity between a solute and soil adsorption sites. Other important parameters controlling the actual amount of solvent adsorbed include soil organic carbon content, soil bulk density, and soil porosity. K_{ow} can also provide an indication of a compound's potential for removal by activated carbon adsorption. Based on these criteria all of the hydrocarbons, except MEK, would be expected to show significant adsorption onto soils.

As discussed above, borings at site have encountered predominantly clay and silts to depths of 25 to 50 feet. Clay and silts have smaller pore sizes and lower conductivity compared to sand and gravel. As a result the vertical diffusion of solvents through clay and silt is highly restricted. This results in solvents being trapped in layers above silt and clay and start spreading horizontally along the layer. The solvents that are able to reach the sand and gravel layer tend to migrate relatively fast to become entrapped in another silt and clay layer. The result is concentrated solvent layers at various depths along the vertical profile of soil.

As shown in Table 2-14, except chlorinated hydrocarbons, all of the major hydrocarbons have specific gravities less than water and therefore will tend to remain in the upper portions of the aquifer while the chlorinated hydrocarbons will sink in the aquifer. However, due to high solubility of the hydrocarbons, most of the hydrocarbons will be distributed over the entire water body.

Biodegradation may be an important environmental fate and treatment option for these compounds under proper operating conditions. Most of the compounds under study are reported to be moderately to completely biodegradable under aerobic conditions. However, little is known about biodegradability of these compounds in aquifers.

Summarizing the above presented discussion, if no action is taken, the hydrocarbons present in groundwater and unsaturated zone soil will tend to remain in the subsurface zones. Due to the lack of any major natural pathway leading to destruction/degradation of these hydrocarbons, migration of hydrocarbons is possible and an anticipated outcome.

REMEDIAL ACTION OBJECTIVES

Based upon the existing subsurface data, and in accordance with the Regional Water Quality Control Board's (RWQCB) "Non-degradation" policy, the following objectives for remediation at the Torrance facility were established:

- Minimize further migration of hydrocarbons from the unsaturated zone to the groundwater.

- Minimize migration of hydrocarbons within the groundwater.

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- Reduce the level of hydrocarbons in the groundwater to provide adequate protection of public health and the environment and to attain applicable, relevant and appropriate requirements (ARAR).

POTENTIAL CLEANUP GOALS

Although this feasibility study is not being conducted under the auspices of the Superfund Program, the procedure used to develop remedial action alternatives follows that recommended by USEPA for Superfund sites and is consistent with the policy of the California Environmental Protection Agency. According to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and the National Contingency Plan (NCP), remedial actions must be protective of human health and the environment and must attain all applicable or relevant and appropriate requirements (ARARs). ARARs are environmental and public health statutes used to determine the appropriate extent of site cleanup and to develop remedial action alternatives at hazardous waste sites. SARA requires that all remedial actions attain compliance with federal ARARs as well as state ARARs if they are more stringent than federal ARARs and if they are legally enforceable and consistently enforced statewide.

An ARAR may be either "applicable" or "relevant and appropriate," but not both. According to the NCP (40CFR Part 300), "applicable" and "relevant and appropriate" are defined as follows:

- Applicable requirements are those cleanup standards of control, or other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at the site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.

- Relevant and appropriate requirements are those cleanup standards, standards of control, or other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that, while "not applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at the site, address problems or situations sufficiently similar to those encountered at the site that their use is well suited to the particular site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be relevant and appropriate.

Where no standards exist for a given chemical or situation, non-promulgated advisories and guidance issued by state or federal government programs may represent criteria or guidelines "to be considered" (TBC) in the feasibility study. Although TBC requirements are not legally binding, they may be evaluated along with ARARs to establish protective cleanup level targets.

The ARARs and TBCs identified for establishing cleanup levels in the groundwater and unsaturated zone soils at the Torrance (C6) site are discussed in the following text.

Groundwater

The ARARs and TBCs associated with the groundwater at the Torrance site include:

- Federal Maximum Contaminant Levels (MCLs) are federally enforceable limits established by the USEPA under the Safe Drinking Water Act (SDWA) enacted in 1974 and amended in 1979 and 1986. The limits were established to protect public health from contaminants that may be found in groundwater that is or may be used for drinking water. Since the RWQCB considers the groundwater to be a potential source of drinking water, federal MCLs are potential ARARs.

- State of California Maximum Contaminant Levels are state enforceable limits for control of contaminants in sources of public drinking water. The state MCLs were established under the California Safe Drinking Water Act of 1976, Health and Safety Code Sections 4010.1(b) and 4026(c).

- California Department of Health Services (DOHS) Applied Action Levels (AALs) are non-enforceable criteria which are intended to be used in the risk appraisal process, and not as the target levels for cleanup. AALs are developed according to the procedures outlined in the California Site Mitigation Decision Tree Manual (DOHS, 1986). AALs are not ARARs since they are not promulgated, and therefore may be used as TBCs to develop cleanup levels if ARARs do not exist. These values are based on the maximum acceptable exposure of biological receptors to substances associated with hazardous waste sites or facilities. AALs are derived by considering health effects without addressing the technical feasibility, economic concerns or other factors.

Table 2-15 lists various numerical requirements and the recommended cleanup goals for each compound detected in the groundwater at the Torrance site. The table also presents the range of concentrations detected and the arithmetic average concentration. As indicated in the table, the state MCLs are generally more stringent and, therefore, are recommended as cleanup goals. Currently, no federal or state MCLs exist for ketones (MEK and MIBK). For this feasibility study, a 1.0 mg/l (total ketones) value has been established as a cleanup goal for ketones.

Soil

Currently, no applicable cleanup standards exist for remediation of solvents in unsaturated zone soils. However, the criteria established in the California Leaking Underground Fuel Tank Field Manual (LUFT Manual) are considered to be relevant and appropriate. Based on the leaching Potential Analysis as described in the LUFT Manual, the target cleanup levels for unsaturated zone soils at the Torrance site are as follows:

TPH	100 mg/kg
Benzene	0.3 mg/kg
Toluene	0.3 mg/kg
Xylene	1.0 mg/kg
Ethylbenzene	1.0 mg/kg

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TABLE 2-15

POTENTIAL CLEANUP GOALS FOR GROUNDWATER

Compound	Concentration Range (ug/l)	Average Concentration (ug/l)	Federal MCL (ug/l)	State MCL (ug/l)	California DOHS AALs (ug/l)	Established Cleanup Goal (ug/l)
1,1-DCE	10-12000	2,342	7	6	ns	6
1,1-DCA	400 (a)	40	ns	5	ns	5
1,1,1-TCA	8-6900	1,234	200	200	300	200
TCE	8-7900	2,200	5	5	7	5
Toluene	7-35000	6,212	1,000	ns	100	1,000
Benzene	nd	nd	5	1	ns	1
cis and trans-1,2-DCE	40-550	59	70	6	ns	6
Methylene Chloride	10-40 (b)	8	5*	ns	40	5
Xylene (all isomers)	nd	nd	10,000	1,750	2,000	1,750
Ethyl Benzene	nd	nd	700	680	2,000	680
MIBK***	17000-70000	8,700	ns	ns	30	**
MEK***	12000-21000	3,300	ns	ns	2,000	**
Chloroform	25-250 (j)	nd	100 (c)	ns	ns	100

Footnotes:

1. ns = No standards exist
2. * = Proposed Standard
   ** = Total ketone effluent concentration of 1.0 mg/l, including MEK and MIBK
   *** = Ketone treatment is optional
3. nd = None detected
4. (a) = The compound was detected in only one well
   (b) = The presence of this compound is uncertain as it was detected in blank samples at similar or higher concentrations
   (c) = Total Trihalomethanes MCL. Includes chloroform, bromoform, bromodichloromethane, dibromochlormethane
   (j) = The concentration is only an estimate as the concentration is lower than the lowest standard

Unfortunately many of the compounds present in soils at the Torrance site (namely chlorinated hydrocarbons and ketones) will not be detected by the analytical method used for TPH analysis. Consequently, the individual target levels may be more appropriate as guidelines in establishing target cleanup levels. The toluene and xylene criteria are particularly useful since toluene was present in 93 percent of samples and xylene in 45 percent of samples. Thus, the above criteria for the specific constituents are recommended as the target cleanup goals. In addition, a cleanup goal of 1 mg/kg is recommended for each chlorinated hydrocarbon and ketone detected at the site.

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Chapter 3

JMM

CHAPTER 3

IDENTIFICATION AND SCREENING OF TECHNOLOGIES

GENERAL RESPONSE ACTIONS

General response actions are defined as those broad measures which would satisfy the remedial action objectives established in Chapter 2. Several response actions have been identified for soil and groundwater cleanup. Although some response actions may be capable of meeting the remedial objectives alone, a combination of response actions may provide the most effective method for unsaturated zone soil and groundwater remediation.

Soil Response Actions

The potential response actions for soil remediation at the Torrance Site include:

- Management
- Containment
- Removal
- On-site treatment
- Off-site treatment
- Disposal

Management. Under this response action, the hydrocarbons in soil would be left in place; but gas monitoring in and around nearby buildings and institutional controls such as restrictions on future construction in the area would be implemented at the site. If high levels of organic vapors are detected in the buildings, additional mitigating measures would need to be taken.

Containment. Containment would consist of capping the solvent-laden soil, installing vertical or horizontal barriers around the soil, or implementing surface controls.

Removal. Removal would involve excavating the solvent-laden soils at the site and then backfilling, compacting and repaving the area. However, excavation of the soil at the site would undermine the foundations of Buildings 1 and 36. Consequently this response action is not considered to be a viable option.

On-site Treatment. On-site treatment would consist of either aboveground or in-situ treatment. Since aboveground treatment would require excavation of the soils, it is not considered a viable option. In-situ treatment would include treating solvent-laden soil without excavation using technologies that specifically act to reduce the potential toxicity of soil hydrocarbons by physical, chemical or biological processes.

Off-site Treatment. Off-site treatment would consist of transporting the solvent-laden soil to an approved facility for ultimate treatment and disposal. Since this response action requires excavation of the soil, it is not considered to be a viable option.

Disposal. Disposal would involve hauling the solvent-laden soil to an approved disposal facility. Since this action would require excavation of the soil as a prerequisite, it is not considered to be a viable option.

Table 3-1 summarizes the general response actions deemed applicable for soil remediation at the Torrance site.

Groundwater Response Actions

The potential response actions for groundwater remediation at the Torrance site include:

- Management
- Containment
- Removal
- On-site treatment
- Off-site treatment
- Discharge

Management. Management of the hydrocarbons in groundwater would include monitoring to track the direction and rate of movement of hydrocarbons. Additional measures such as restricting groundwater use in the vicinity of the site may be enacted to prevent exposure under future land use scenarios. Deed restrictions may also be implemented to limit future use of the site.

Containment. Containment would involve implementing technologies that provide protection of human health and the environment by reducing the mobility of hydrocarbons. Thus, containment technologies attempt to reduce potential routes of exposure by minimizing the spread of hydrocarbons through active or passive gradient controls. Active gradient controls typically consist of pumping wells or drains, whereas passive gradient controls typically include low permeability barriers.

Removal. Removal would involve the extraction of groundwater for subsequent treatment and/or disposal. The groundwater would be extracted from the aquifer through a system of pumped wells, drains or trenches.

On-site Treatment. On-site treatment would be accomplished either aboveground or in-situ. Aboveground treatment would be used in combination with a groundwater removal action and would employ technologies which specifically act to reduce the mobility, toxicity, and volume of hydrocarbons by physical, chemical or biological processes. In-situ treatment would involve treating the hydrocarbons in groundwater in place thus eliminating the need for extraction.

Off-site Treatment. Off-site treatment would involve transporting extracted groundwater to an approved facility or directly discharging to a POTW for ultimate treatment and disposal.

Discharge. This response action involves discharging treated groundwater to a sewer or a surface water body such as a flood control channel, or reinjecting the treated groundwater into the aquifer or reuse for industrial purposes.

Table 3-1 summarizes the general response actions deemed applicable for groundwater remediation at the Torrance site.

TABLE 3-1

GENERAL RESPONSE ACTIONS APPLICABLE FOR THE TORRANCE SITE

Soil Response Actions

- Management
- Containment
- In-situ Treatment

Groundwater Response Actions

- Management
- Containment
- Removal
- On-site Treatment
- Off-site Treatment
- Discharge

REMEDIAL ACTION TECHNOLOGIES

A variety of remedial technologies are available for potential use at the Torrance site to address the remedial action objectives established in Chapter 2 . The applicability of each technology depends on the project objectives, as well as site and waste characteristics. Information on hydrocarbon types and concentrations and on site characteristics as presented in the Phase II and Phase III field investigations by WCC and further analytical data collected by JMM (as part of this FS) are used to screen technologies and process options on the basis of effectiveness, demonstrated performance and implementability. Technologies and process options that could not be effectively implemented at the site are eliminated. The purpose of this screening step is to produce an inventory of suitable technologies and process options that can be assembled into remedial alternatives capable of removing the hydrocarbons in soil and groundwater at the Torrance Facility.

A variety of sources were drawn on to identify the potential technology options. Primary sources included several EPA documents regarding remedial technologies, API documents, experience in developing other feasibility studies, scientific journals and books, and information from vendors.

The following candidate technologies were selected for the technology screening process:

Soil Remediation Technologies

Management. The management options include institutional controls to restrict future use and monitoring activities.

- Restrictions on Future Construction

Restrictions on future construction would be incorporated into the deed for the property in order to avoid future exposure to hydrocarbons.

- Gas Monitoring

Gas monitoring probes would be installed beneath and inside the nearby structures. Routine monitoring of selected hydrocarbons would then be conducted. If hydrocarbons levels increase beyond the maximum allowable, additional mitigating measures such as increased ventilation in the building or soil gas venting below the building slab would need to be implemented.

Containment. The containment options involve installation of physical barriers to minimize or prevent migration of hydrocarbons in soil. Since the volume and toxicity of hydrocarbons is not reduced by containment, long-term monitoring is typically required and additional remedial action may be required in the future. For this reason, containment options are typically combined with management/monitoring technologies and/or treatment or disposal technologies. The available containment options include:

- Capping

Capping is the placement of a low permeability surface over a site to minimize infiltration of rain water down through the soil column and to minimize the migration and release of vapors into nearby structures or to the atmosphere. Soil hydrocarbons which are immobilized by eliminating the flushing action of infiltration and the outlet for vapors are effectively contained by the capping process. Capping may also reduce recharge to an aquifer and slow the migration of groundwater hydrocarbons. Typical caps consist of soils (usually clay), asphalt, concrete, and synthetic membranes.

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- Surface Controls

Surface controls are typically combined with capping to reduce the infiltration of surface water into the soil column. Minimizing infiltration reduces the mobility of hydrocarbons in soil. Surface control methods include installation of barriers to intercept and divert runoff from precipitation and site grading to enhance drainage or to prevent run-on.

- Horizontal Barriers

Horizontal barriers act as a floor beneath solvent-laden soil to prevent hydrocarbons from migrating down to the water table. The placement of horizontal barriers, also known as bottom sealing, is usually accomplished using jet grouting or block displacement techniques. These processes inject grout into the soil to form a physical barrier to vertical hydrocarbon migration. This technology is currently in an experimental stage of development, and it is difficult to verify the integrity of the barrier.

- Vertical Barriers

Vertical barriers physically block the lateral migration of hydrocarbons within the soil. Typical vertical barrier technologies include slurry walls and grout curtains, which form a cementitious barrier, and sheet piles. Vertical barriers are very difficult to install and are not very effective at sites containing silty soils.

Presently, the area of solvent-laden soil at the Torrance site is covered with asphalt paving and concrete slabs. This surface should serve as an adequate cap for reducing infiltration of rain water, but may not effectively control the upward migration and release of organic vapors into nearby structures. Vapors could penetrate joints, cracks or pipe penetrations in the concrete and accumulate within the buildings. Since the containment technologies would not accomplish any reduction of potential toxicity, volume or volatility of the hydrocarbons, the solvent-laden soil would remain a source of organic vapors for a long period of time. Installation of an impermeable membrane beneath the buildings to enhance the integrity of the existing cap is not practical. However, a program could be implemented to identify and seal any cracks or penetrations which could act as potential conduits for vapor migration.

Although the existing cap will eliminate the potential for flushing of hydrocarbons from the soil to the groundwater, the hydrocarbons currently present in the capillary fringe continue to act as a source of hydrocarbons. Horizontal barriers would not be practical for this application and would likely not be very effective due to the hydrocarbon proximity to the groundwater. Vertical barriers are also not viable for this application since no significant lateral migration of the hydrocarbons is expected in the vadose zone.

In summary, none of the containment technologies will be retained for further evaluation since a cap and surface controls already exist and the remaining technologies are not applicable to the site conditions.

In-Situ Treatment. In-situ soil treatment options accomplish remediation of hydrocarbons in soil in-place, eliminating costly excavation, handling, and disposal. However, in-situ treatment processes tend to be more complex than ex-situ processes, and the cost savings may be offset by the potential for failure. Consequently, thorough knowledge of actual subsurface conditions and some on-site treatability testing are essential to complete an evaluation of their feasibility. The in-situ soil treatment options include:

Physical Treatment

- Soil Flushing

Soil flushing is the in-situ counterpart to ex-situ soil washing. The method involves flooding a site with an appropriate solution to mobilize or emulsify hydrocarbons in soil. Shallow recovery wells or drain fields are used to recover the solution and hydrocarbons. This technology may be used in conjunction with groundwater extraction and treatment and is most applicable for sites where hydrocarbons have already impacted groundwater. Soil flushing is very dependent on soil properties and has limited demonstrated performance. The soils identified at the Torrance site are relatively low permeability soils which are not amenable to flushing. In addition, the site is paved and contains existing structures, making soil flushing difficult to implement. Consequently, this technology was not retained for further consideration.

- Soil Vapor Extraction

Soil vapor extraction is carried out in-situ by forcing ambient air through the soil using air extraction wells or a combination of air injection and extraction wells at a number of locations. The process is generally effective in removing volatile organic compounds which meet the following selection criteria (Sims 1990):

(1) Vapor pressure greater than 14-mm Hg at 20 C for liquid phase hydrocarbons; and;

(2) dimensionless Henry's constant greater than 0.01 for aqueous phase hydrocarbons.

Most of the hydrocarbons detected at the Torrance site meet both of these criteria. The exceptions include ethylbenzene, xylene and MIBK which have lower vapor pressures, and MEK which has a low Henry's constant. Since ethylbenzene and xylene have Henry's constants above the listed criterion, significant removals can probably be accomplished through soil vapor extraction. In fact, studies reported in the literature confirm the applicability of this technology for ethylbenzene and xylene. Some treatability testing would be necessary to confirm removals for the ketones. However, the ketones present less of a hazard than the aromatics or chlorinated hydrocarbons, since they are less toxic and can readily biodegrade. This technology was retained for further consideration.

- Steam Stripping

In-situ steam stripping is a recently developed technology for remediation of soils containing hydrocarbons and solvents which do not have sufficient volatility for removal using soil vapor extraction. The process injects an air/steam mixture through rotating

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cutting blades mounted on two hollow-stem drills. Hydrocarbons are stripped and conveyed to the ground surface, where they are recovered, condensed, and distilled out as an oily waste stream. The technology is still in the development stage and has low commercial availability. Access for the drill rig would also be a limitation due to the existence of structures over the area of hydrocarbon plume. This technology was not retained for further consideration.

- Radio Frequency Heating

This emerging process uses electromagnetic wave energy in the radio frequency range to heat the waste and vaporize hydrocarbons. A vapor containment cover is placed over the treatment area to recover hydrocarbon vapors. This process has been developed at the experimental stage only and was not retained for further consideration.

Chemical Degradation

- Ultraviolet Photolysis

Ultraviolet photolysis uses intense light over a large range of wavelengths to excite electrons in hydrocarbons, causing the substances to become unstable and decompose. The process must expose all hydrocarbons to direct light to be effective. The process is highly experimental for treatment of solvent-laden soils and would be difficult to implement. This technology was not retained for further consideration.

- Chemical Hydrolysis

Chemical hydrolysis brings otherwise insoluble hydrocarbons into ionic solution with water by breaking molecular bonds in substances. The resulting solution normally requires further treatment to remove toxicity. Typical hydrolytic agents include acids, ultraviolet light, and enzymes. The process is highly experimental for treatment of solvent-laden soils and was not retained for further consideration.

- Chemical Oxidation and Reduction

Chemical oxidation and reduction processes remove or add electrons from/to hydrocarbons, causing them to react with desired reagents. Hydrocarbons are transformed ultimately into carbon dioxide and water. A wide range of oxidants are available, including ozone, hydrogen peroxide and chlorine. Chemical oxidation and reduction is widely used for treatment of aqueous wastes but has not been fully demonstrated for solvent-laden soils. The low permeability of the soils at the site also creates a significant limitation for this technology. This technology was not retained for further consideration.

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Biological Degradation

- Liquid-Phase Bioremediation

Bioremediation uses microorganisms to degrade hydrocarbons. The process enhances the rate of biological degradation by controlling environmental factors including: food sources, moisture content, pH, temperature, oxygen, and nutrients. In-situ liquid-phase bioremediation is performed by applying a solution of nutrients and an oxygen source to the soil with percolation wells/trenches, extracting groundwater downgradient and recycling it through the soil. This technology is most applicable for sites where hydrocarbons have already impacted the groundwater. However, bioremediation has not been successfully demonstrated for chlorinated hydrocarbons (e.g., 1,1-DCE, DCA, TCA, TCE, etc.) which dominate the hydrocarbon population at the Torrance site. Most of the studies done to this effect are either in the experimental stage or being tested currently in field situations. Due to this lack of sufficient information on biodegradation of chlorinated hydrocarbons, the technology was not retained for further consideration.

- Bioventing

Bioventing combines the capabilities of soil venting and enhanced bioremediation to cost effectively remove hydrocarbons from vadose zone soils and the groundwater table. Soil venting removes the more volatile components from unsaturated soil and promotes aerobic biodegradation by driving large volumes of air into the subsurface. In theory, air is several thousand times more effective than water in penetrating and aerating fuel-saturated and low permeability soil horizons. Aerobic microbial degradation can mitigate both residual and vapor phase hydrocarbon concentrations. In summary, bioventing is a combination of soil vapor extraction and bioremediation techniques. As discussed above, bioremediation does not appear to be a potential technology for removing hydrocarbons at the Torrance site. Therefore bioventing does not offer any additional advantages over soil vapor extraction. However bioventing does add to the problems in terms of generating microbial byproducts as a result of biodegradation. These unknown byproducts, if any, could add to hydrocarbon concentrations in soil. In addition, bioventing requires injection of air into soils. The injected air tends to create a zone of positive pressure, forcing the air to escape out and in the process carrying potentially toxic hydrocarbons along with it, creating a potential hazard to human health. This technology was not retained for further consideration.

Solidification/Stabilization

A wide range of solidification/stabilization processes are available for treating hydrocarbons in soils. The solidification/stabilization process options are as follows:

- Cement-Based Processes

In-situ cement-based solidification incorporates hydrocarbons into a cement matrix by mixing the soil with the cement in-place. Water added to the soil reacts chemically with Portland cement to form hydrated silicate and alumina compounds. The final product is

Chapter 4

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CHAPTER 4

DEVELOPMENT OF REMEDIATION ALTERNATIVES

SCREENING OF TECHNOLOGIES

The main objective of this feasibility study is to evaluate remedial alternatives for soil and groundwater at the DAC Torrance Facility which will assure adequate protection of human health and the environment. General response actions for hydrocarbon mitigation at the site include options for management, containment, treatment and/or disposal of groundwater and unsaturated zone soil. In Chapter 3, candidate remedial technologies that may be applicable for the management, containment, treatment or disposal of the hydrocarbons were identified. These remedial technologies were screened according to site-specific criteria to determine which of the technologies were best suited for the site conditions and cleanup objectives. Table 4-1 provides a list of the remedial technologies determined to be applicable for remediation of soil and groundwater bound hydrocarbons at the Torrance (C6) Facility.

Table 4-1 suggests that for soil management and in-situ treatment only one candidate technology was retained for each option after initial screening, indicating that only a single technology was considered feasible for each of these options. However, several technologies passed the initial screening criteria for groundwater treatment and vapor phase treatment. These technologies were further screened based on the following criteria:

- Performance
- Reliability
- Implementability
- Safety
- Environmental inpacts, and
- Costs

A separate screening was performed for groundwater and vapor treatment technologies. Tables 4-2 and 4-3 summarize the screening process for groundwater and vapor treatment, respectively.

From Table 4-2, it can be noted that all identified technologies are capable of treating the groundwater to meet the cleanup objectives stated in Chapter 2. All identified technologies are established technologies offering the same degree of reliability and with similar implementability requirements. The air stripping process has low O&M requirements compared to other technologies, but will require further treatment downstream in order to meet the SCAQMD emissions limit. The GAC system will produce hazardous waste requiring disposal or regeneration. Therefore, it can be concluded that all identified technologies will accomplish abatement of hydrocarbons with essentially the same effectiveness and implementability. In a situation like this, the cost of implementing a remedial technology becomes an important element in selection of a final candidate remedial technology.

TABLE 4-1

SUMMARY OF APPLICABLE REMEDIAL TECHNOLOGIES

General Response Action	Technology
Soil Response Action	
Management	Gas Monitoring
In-situ Treatment	Soil-Vapor Extraction System
Groundwater Response Action	
Ex-situ Treatment	Carbon Adsorption - Off-site Regenerable Air Stripping Steam Stripping Advanced Oxidation Process
Groundwater Discharge	Discharge to a Sanitary Sewer Surface Water Discharge (Option)* Groundwater Recharge (Option)* Industrial Water Use (Option)*
Ketone Removal (Option)*	Rotating Biological Contactor
Vapor phase Treatment	Carbon Adsorption - Off-site Regeneration Carbon Adsorption - On-site Regeneration Adsorption-Desorption Process Catalytic Oxidation Process

* = Ketone removal will be required to use these options

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Table 4-2
SUMMARY OF TECHNOLOGY SCREENING
GROUNDWATER REMEDIATION

Criteria	Air Stripping	Steam Stripping	Advanced Oxidation	Carbon Adsorption
PERFORMANCE				
Effectiveness at meeting cleanup objectives	Effective removal of volatile and semivolatile organics	Effective removal of volatile and many semivolatile organics	Effective removal of volatile and many semivolatile organics	Effective removal of volatile and semivolatile organics
RELIABILITY				
Process Complexity	Very simple	Somewhat complex	Complex	Relatively simple
O & M requirements	Low	Moderate	Moderate to high	Low to moderate
Process Flexibility	Good flexibility to handle variable influent	Good flexibility to handle variable influent	Little flexibility to handle variable influent	Good flexibility to handle variable influent
Probability of failure or shutdown	Process is very stable	More likely that shutdowns could be necessary to maintain the system	Very likely that incomplete treatment could occur during shock loads	Process is very stable
IMPLEMENTATION				
Contractibility	Easy	Fairly easy	Complex	Easy
Time to construct	5-6 months	6-8 months	8-10 months	5-6 months
SAFETY	Operators could be exposed to VOC emissions unless proper precautions are taken or offgases are collected	Operators could be exposed to VOC emissions unless proper precautions are taken or offgases are collected	Most chemical oxidants require special storage and handling	None

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Table 4-2 (Continued)
SUMMARY OF TECHNOLOGY SCREENING
GROUNDWATER REMEDIATION

Criteria	Air Stripping	Steam Stripping	Advanced Oxidation	Carbon Adsorption
ENVIRONMENTAL IMPACTS				
Generation of noise and odors	Minor noise associated with blowers. Odors maybe generated if biofouling occurs	Some noise associated with pumps and steam system. Odors may be generated if offgases are not collected.	Minor noise associated with pumps	Minor noise associated with pumps. Odors maybe generated if biofouling occurs
Air pollution	VOCs will be emitted if offgases are not collected and treated	VOCs will be emitted if offgases are not collected and treated	None	None
Generation of Residuals	The liquid phase treatment does not generate residuals, but the vapor phase treatment system may depending on the technology selected.	Process generates a concentrated organic mixture which would need to be recycled or disposed	None	The spent carbon would be considered hazardous waste and would require proper regeneration or disposal
COSTS (Liquid Phase Treatment Only)				
Capital	Low	High	Moderate to high	Low
O & M	Low	Moderate to high	Very high	Very high

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Table 4-3
SUMMARY OF TECHNOLOGY SCREENING
VAPOR TREATMENT

Criteria	G A C (Off - site Regeneration)	G A C (On - site Regeneration)	Catalytic Oxidation	Resin Adsorption Desorption
PERFORMANCE				
Effectiveness at meeting discharge standards	Effective removal of chlorinated hydrocarbons and aromatics	Effective removal of chlorinated hydrocarbons and aromatics	Effective removal of chlorinated hydrocarbons and aromatics	Effective removal of chlorinated hydrocarbons and aromatics
RELIABILITY				
Process Complexity	Relatively simple	Somewhat complex	Somewhat complex	Relatively simple
O & M requirements	Low	Moderate	Moderate	Moderate
Process Flexibility	Good flexibility to handle variable influent	Good flexibility to handle variable influent	Less flexibility to handle variable influent	Good flexibility to handle variable influent
Probability of failure or shutdown	Process is very stable	Process is very stable	More likely that incomplete treatment could occur during shock loads	Process is very stable
IMPLEMENTATION				
Contractibility	Easy	Relatively easy	Relatively easy	Relatively easy
Time to construct	5-6 months	7-9 months	6-8 months	8-10 months
SAFETY	Relatively safe	Relatively safe	Relatively safe	Relatively safe

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Table 4-3 (Continued)
SUMMARY OF TECHNOLOGY SCREENING
VAPOR TREATMENT

Criteria	G A C (Off - site Regeneration)	G A C (On - site Regeneration)	Catalytic Oxidation	Resin Adsorption Desorption
ENVIRONMENTAL IMPACTS				
Generation of noise	Minor noise associated with pumps	Minor noise associated with pumps and steam system.	Minor noise associated with pumps	Minor noise associated with pumps
Generation of Residuals	The spent carbon would be considered hazardous waste and would require proper disposal or regeneration	The condensate would be considered hazardous waste and would require proper disposal	Process will generate a small waste stream suitable for discharge to sewer	Process generates a concentrated organic mixture which would need to be recycled or disposed
COSTS (Vapor Phase Treatment Only)				
Capital	Low	High	Moderate to high	Moderate
O & M	Very high	Moderate	Moderate	Low

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From Table 4-3, a similar conclusion can be drawn about the identified vapor treatment technologies. Consequently, the cost to implement the remedial technology becomes an important element.

The preliminary cost estimates were developed for each of the groundwater and vapor phase treatment technologies identified in Tables 4-2 and 4-3. The cost estimates were based on vendor information and experience in developing cost estimates for similar projects. In order to compare different technologies capable of achieving the cleanup objectives, several assumptions had to be incorporated in the cost analysis:

Groundwater Treatment

- The total flowrate from all extraction wells was assumed to be 100 gallons per minute (gpm).

- The weighted average concentration of each compound was assumed as the influent concentration to be treated.

- The groundwater discharge criteria was based on 1.0 mg/l total toxic organics, except ketones. The ketones are currently not regulated under the CSDLAC discharge criteria which has been considered as the primary discharge option. In order to utilize other discharge options, specifically surface water discharge or the groundwater recharge or industrial water reuse, additional groundwater treatment for ketone removal will be required in order to meet the NPDES permit requirements. At present, no state regulations exist for ketone levels in the discharge waters. A total ketone concentration of 1.0 mg/l has been established for treatment purpose in this feasibility study. The cost for ketone removal will be the same for all alternatives and has not been included in the alternatives cost estimate.

- The capital investment and operating cost for each technology were based on the assumption of complete groundwater treatment and hydrocarbon destruction/disposal through each technology (e.g., air stripping would require an off-gas treatment system, such as a catalytic oxidation process followed by a caustic scrubber. So the capital and operating cost of an off-gas treatment system had to be added to the capital and operating cost of an air stripper, respectively).

Vapor Phase Treatment

- Soil-vapor extraction system was assumed to produce 650 scfm flowrate.

- The total flowrate of air stripper off-gas was assumed to be 800 scfm.

- Each technology was evaluated for treatment of SVE system alone and SVE system and air stripper off-gas flowrate combined.

- The discharge criteria for treated air were based on the South Coast Air Quality Management District (SCAQMD) guidelines.

- The operating life of the SVE system was assumed to be five (5) years.

- The capital investment and operating cost for each technology were based on the assumption of complete soil-vapor treatment and hydrocarbon destruction/disposal through each technology (e.g., catalytic oxidation process would require a caustic scrubber for hydrochloric acid generated during the process. So the capital and operating cost of a caustic scrubber had to be added on to the capital and operating cost of a catalytic oxidation system, respectively).

With the above mentioned assumptions, the capital investment and the annual operating cost of various soil remediation technologies along with a 5-year present worth analysis is presented in Table 4-4. The cost estimates have been developed for the SVE system alone and for a combined SVE and air stripper off-gas system. This will facilitate a better cost comparison of different alternatives at a later stage. A similar analysis for groundwater treatment technologies is presented in Table 4-5. The groundwater treatment system is expected to have a longer operating life compared to a vapor phase treatment system, and thus the present worth analysis has been performed for up to 30 years.

Based on cost estimates presented in Tables 4-4 and 4-5, the treatment technologies considered to be cost-effective for groundwater and unsaturated zone soil remediation are shown in Table 4-6. These candidate remedial technologies were assembled into specific response alternatives presented below. These alternatives represent combinations of the remedial technologies that could be employed as overall control measures for groundwater and unsaturated zone soil remediation.

DEVELOPMENT AND DESCRIPTION OF REMEDIATION ALTERNATIVES

The technology screening in Chapter 3 identified a soil-vapor extraction system to be the only technically feasible soil response action capable of mitigating the hydrocarbons at the site. This treatment system has been included in all alternatives presented. Similarly for the groundwater response action, pump and treat is the only groundwater treatment technology that could effectively meet the cleanup objectives. For the groundwater flowrate established for the extraction (pumping) system, an air stripper was found to be the most attractive treatment technology, and is included in all of the alternatives presented. In each alternative, off-gas from the air stripper has been combined with the SVE system for vapor phase treatment. A fixed-film bioreactor, such as a RBC, is considered the most feasible option for removal of ketones from the groundwater to cleanup objectives if the discharge options of surface water, groundwater recharge or industrial water use are considered. Therefore, a fixed-film bioreactor will be considered for the ketone removal option with each alternative. The specific response alternatives, therefore, differ primarily in the technologies considered for vapor phase treatment and disposal of the hydrocarbons generated during the treatment process.

Based on previous technology screenings, three alternatives were developed for groundwater and unsaturated zone soil remediation, as presented in this section. Detailed analysis of

TABLE 4-4

ECONOMIC EVALUATION OF VAPOR PHASE TREATMENT TECHNOLOGIES

Technology	SVE System			Combined SVE System and Air Stripper Off-gas		
	Capital Investment	Annual Cost	5 Year Present Worth	Capital Investment	Annual Cost	5 Year Present Worth
GAC with Off-site Regeneration	$120,000	$495,000	$1,751,575	$120,000	$702,000	$2,429,678
GAC with On-site Regeneration Recycling cost	$265,000	$62,000	$465,458	$390,000	$86,000	$669,914
Catalytic Oxidation Process Scrubber for HCl treatment Chemical storage Heat exchanger	$175,000	$60,000	$402,460	$240,000	$87,000	$526,587
Resin Adsorbtion-Desorption Process (PADRE) Recycling cost	$115,000	$40,000	$234,938	$175,000	$56,000	$349,830

1. Steam was assumed to be available on-site. Cost for steam generation reflects only the associated fuel cost.
2. 100 percent hydrocarbons recycled.
3. Present worth analysis based on 10 percent annual compound interest.
4. Capital investment is for vapor phase treatment equipment only. Annual cost is for hydrocarbon treatment only.
5. Assuming air compressor is available on-site.
6. Annual cost is for Year-1. Annual cost for subsequent years will be lower due to decreasing hydrocarbon concentration.

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TABLE 4-5

ECONOMIC EVALUATION OF GROUNDWATER TREATMENT TECHNOLOGIES

Alternative	Capital Investment	Annual Cost	5 Year Present Worth	10 Year Present Worth	20 Year Present Worth	30 Year Present Worth
GAC with Off-site Regeneration	$120,000	$740,000	$2,925,340	$4,666,560	$6,420,360	$7,095,980
Air Stripping Off-gas treatment by resin adsorption-desorption process Chemical storage Anti-scaling agent	$215,000	$63,000	$453,833	$602,072	$751,382	$808,901
Steam Stripping Organic Phase Separator Recycling cost	$510,000	$135,000	$1,021,785	$1,339,440	$1,659,390	$1,782,645
Advanced Oxidation Process	$510,000	$270,000	$1,533,570	$2,168,880	$2,808,780	$3,055,290

1. Steam was assumed to be available on-site. Cost for steam generation reflects only the associated fuel cost.
2. 100 percent hydrocarbons recycled.
3. Present worth analysis based on 10 percent annual compound interest.
4. Capital investment is for groundwater treatment equipment only. Annual cost is for hydrocarbon treatment only.
5. Assuming air compressor is available on-site.
6. Annual cost is for Year-1. Annual cost for subsequent years will be lower due to decreasing hydrocarbon concentration.

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TABLE 4-6

SUMMARY OF COST EFFECTIVE REMEDIAL TECHNOLOGIES

General Response Action	Technology
Soil Response Action	
Management	Gas Monitoring
In-situ Treatment	Soil-Vapor Extraction System
Groundwater Response Action	
Ex-situ Treatment	Air Stripping
Groundwater Discharge	Discharge to a Sanitary Sewer Surface Water Discharge (Option)* Groundwater Recharge (Option)* Industrial Water Use (Option)*
Ketone Removal (Option)*	Fixed-Film Bioreactor
Vapor Phase Treatment	Carbon Adsorption - On-site Regeneration Adsorption-Desorption Process Catalytic Oxidation Process

* = Ketone removal will be required to use these options

the alternatives is presented in Chapter 5 of this report and will form the basis for a comparative evaluation of the specific response alternatives.

Alternative 1: Groundwater Treatment with Air Stripper/Vapor Phase Treatment with Carbon Adsorption with On-site Regeneration

This alternative would include the following processes.

- Soil-Vapor Extraction
- Carbon Adsorption of Vapor Phase
- Groundwater Extraction
- Groundwater Treatment with Air Stripper
- Off-gas Treatment by Carbon Adsorption
- Recycling of Organic Compounds
- Disposal of Treated Groundwater to a Sewer
- Discharge of Treated Air Stream
- Ketone Removal with a Rotating Biological Contactor (for other disposal options)

Alternative 1 would reduce the level of hydrocarbons in the unsaturated zone by inducing a flow of air through the soil to vaporize the volatile hydrocarbons. Hydrocarbons would be removed from the resulting air stream using an activated-carbon system. A vapor extraction pilot test will be required to determine the actual radius of influence which can be achieved by each vapor well.

Groundwater extraction wells would pump groundwater to the surface for treatment. Pumping groundwater from the aquifer gradually removes the hydrocarbons from the aquifer. An additional pump test needs to be performed prior to implementing this alternative to verify that adequate groundwater recovery rates can be achieved with each well.

Counter-flow, packed tower air stripping would be employed for groundwater treatment. Air stripping will remove 99 percent of the aromatics and chlorinated hydrocarbons and transfer them to the air stream. The majority of ketones (MEK and MIBK) will remain in the liquid stream. The vapor stream would then pass through an activated-carbon system where the hydrocarbons would be adsorbed on the carbon surface. The treated air would be emitted to the atmosphere.

Spent carbon would be regenerated on-site using steam. The condensate from GAC unit would be sent to a recycling unit.

Treated groundwater would be discharged to a sanitary sewer. Additional treatment for ketone removal will be required for disposal of treated groundwater to a surface drain, or reuse for groundwater recharge or industrial purposes. Ketone removal has been

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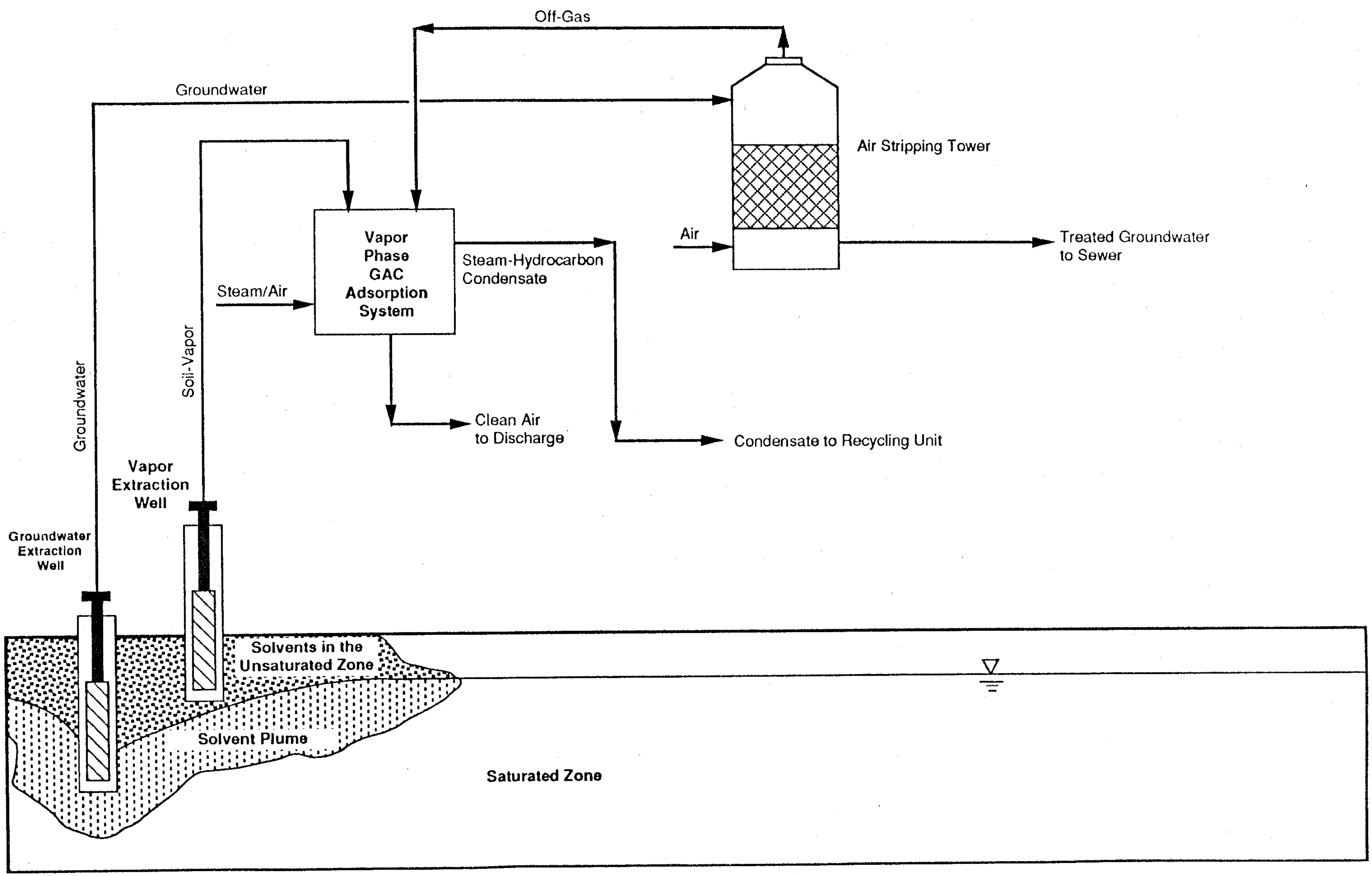

Douglas Aircraft Company
Torrance (C6) Facility
Carbon Adsorption Treatment System
Alternative 1
Figure 4-1

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considered as an option in this feasibility study, and therefore, is not presented with the treatment alternative.

A flow schematic for the air stripping/carbon adsorption alternative is presented in Figure 4-1.

Alternative 2: Groundwater Treatment with Air Stripper/Vapor Phase Treatment with Catalytic Oxidation and Caustic Scrubber

This alternative would include the following processes.

- Soil-Vapor Extraction
- Catalytic Oxidation of Vapor Phase
- Groundwater Extraction
- Groundwater Treatment with Air Stripper
- Off-gas Treatment by Catalytic Oxidation
- Caustic Scrubbing of Vapor Stream
- Disposal of Treated Groundwater to a Sewer
- Discharge of Treated Air Stream
- Ketone Removal with a Rotating Biological Contactor (for other disposal options)

Alternative 2 would reduce the level of hydrocarbons in the unsaturated zone by inducing a flow of air through the soil to vaporize the volatile hydrocarbons. Hydrocarbons would be removed from the resulting air stream using a catalytic oxidation process. A vapor extraction pilot test will be required to determine the actual radius of influence which can be achieved by each vapor well.

Groundwater extraction wells would pump hydrocarbons containing groundwater to the surface for treatment. Pumping groundwater from the aquifer gradually removes the hydrocarbons from the acquifer. An additional pump test needs to be performed prior to implementing this alternative to verify that adequate recovery rates can be achieved with each well.

Counter-flow, packed tower air stripping would be employed for groundwater treatment. Air stripping will remove 99 percent of the aromatics and hydrocarbons and transfer them to the air stream. The majority of ketones (MEK and MIBK) will remain in the liquid stream. The vapor stream would then pass through a catalytic oxidation where hydrocarbons would be converted to by-products like water and carbon dioxide and hydrochloric acid.

The combined air stream from catalytic oxidation unit would then pass through a caustic scrubber where hydrochloric acid would be neutralized with a caustic soda solution. The treated air stream would be emitted to the atmosphere.

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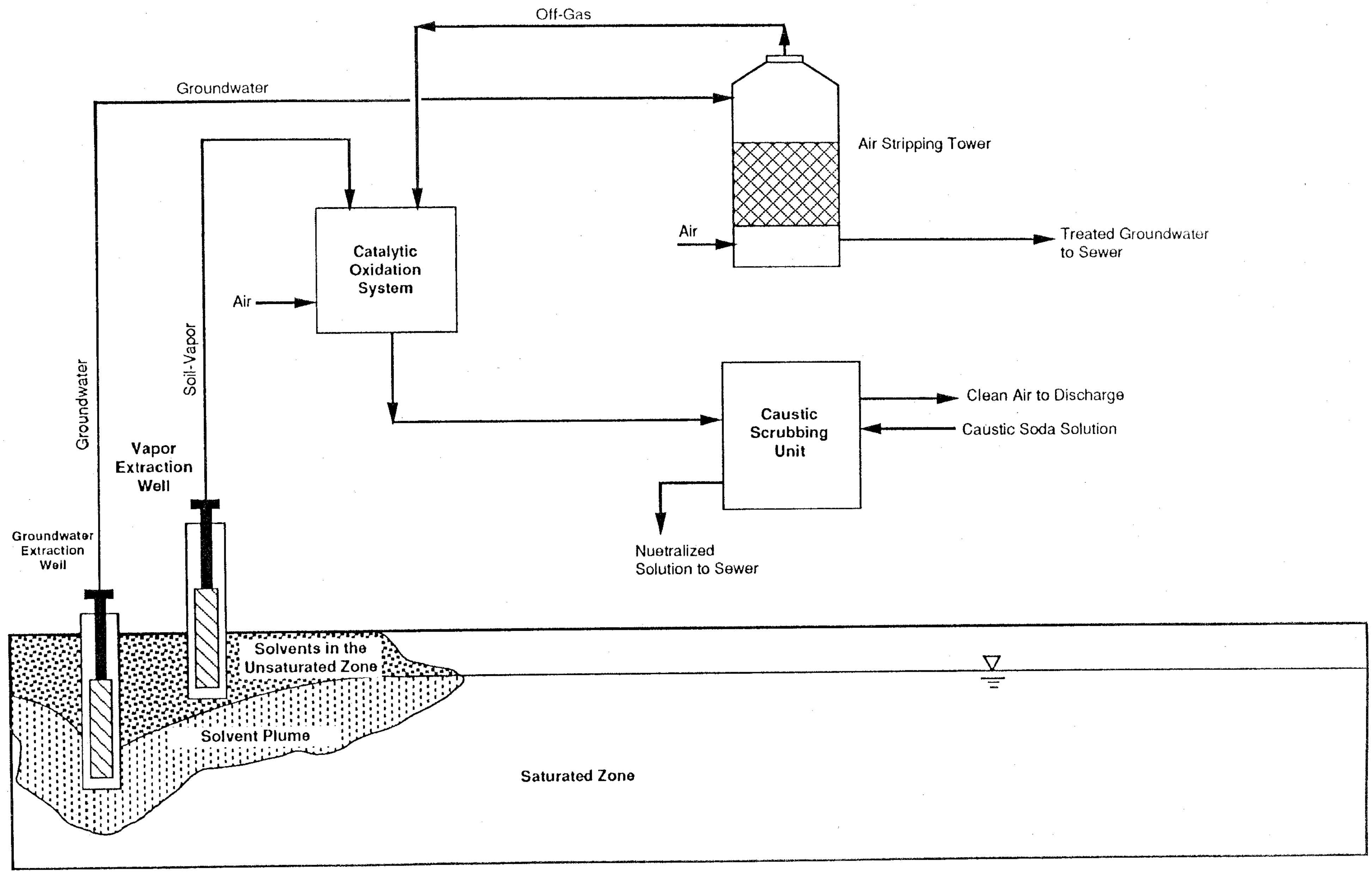

Douglas Aircraft Company
Torrance (C6) Facility
Catalytic Oxidation Treatment System
Alternative 2
Figure 4-2

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Treated groundwater would be discharged to a sanitary sewer. Additional treatment for ketone removal will be required for disposal of treated groundwater to a surface drain, or reuse for groundwater recharge or industrial purposes. The ketone removal has been considered as an option in this feasibility study, and therefore, is not presented with the treatment alternative.

A flow schematic for the air stripping/catalytic oxidation alternative is presented in Figure 4-2.

Alternative 3: Groundwater Treatment with Air Stripper/Vapor Phase Treatment with Resin Adsorption-Desorption Process

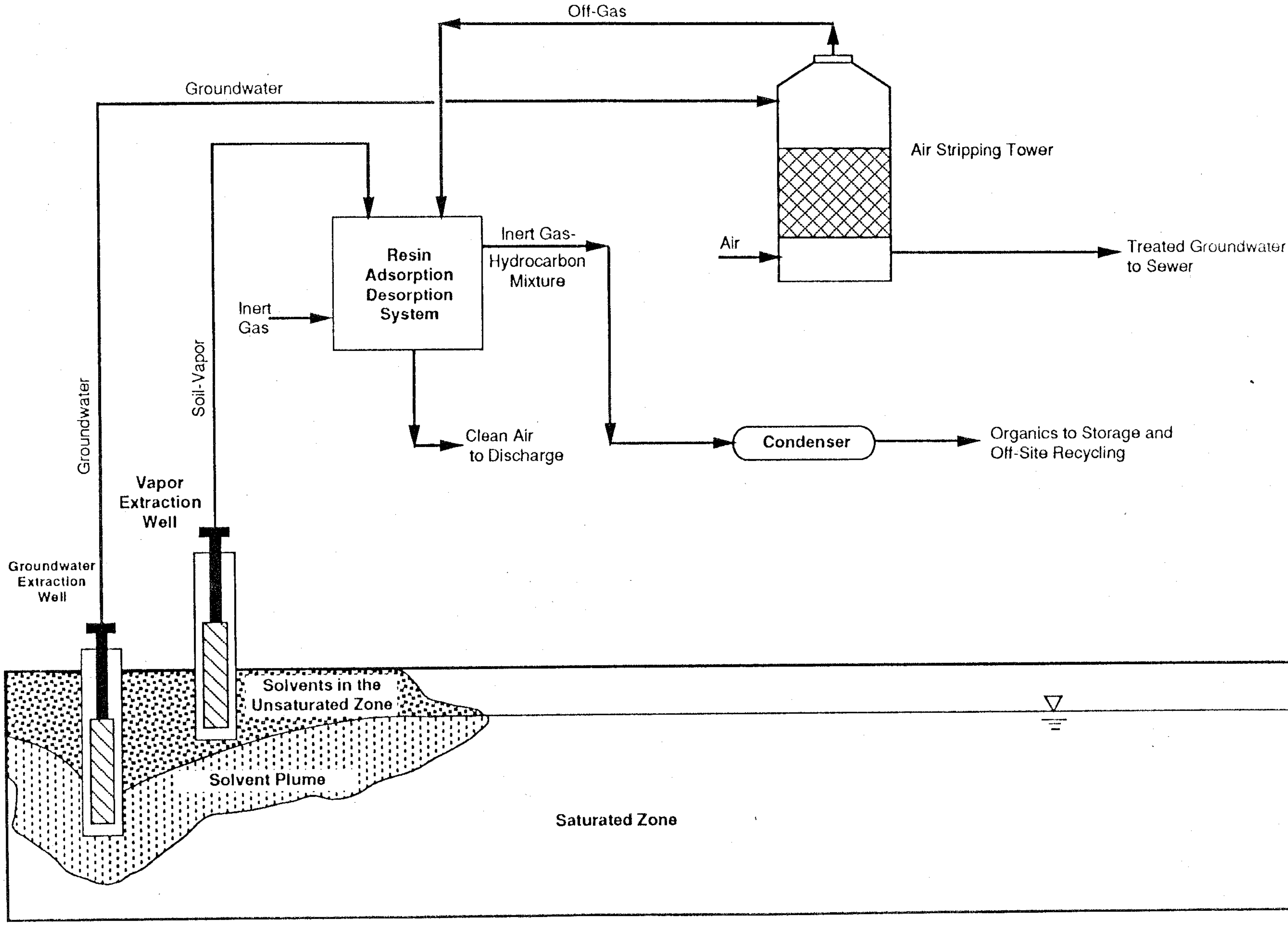
This alternative would include the following processes.

- Soil-Vapor Extraction
- Resin Adsorption of Vapor Phase
- Groundwater Extraction
- Groundwater Treatment with Air Stripper
- Off-gas Treatment by Resin Adsorption
- Desorption of Resin Bed
- Recycling of Organic Compounds
- Disposal of Treated Groundwater to a Sewer
- Discharge of Treated Air Stream
- Ketone Removal with a Rotating Biological Contactor (for other disposal options)

Alternative 3 would reduce the level of hydrocarbons in the unsaturated zone by inducing a flow of air through the soil to vaporize the volatile hydrocarbons. Hydrocarbons would be removed from the resulting air stream using a resin adsorption process. A vapor extraction pilot test will be required to determine the actual radius of influence which can be achieved by each vapor well.

Groundwater extraction wells would pump hydrocarbon-containing groundwater to the surface for treatment. Pumping groundwater from the aquifer gradually removes the hydrocarbons from the acquifer. An additional pump test needs to be performed prior to implementing this alternative to verify that adequate recovery rates can be achieved with each well.

Counter-flow, packed tower air stripping would be employed for groundwater treatment. Air stripping will remove 99 percent of the aromatics and chlorinated hydrocarbons and transfer them to the air stream. The majority of ketones (MEK and MIBK) will remain in the liquid stream. The vapor stream would then pass through a resin adsorption system where the hydrocarbons would be adsorbed on the resin bed. The treated air would be emitted to the atmosphere.



Douglas Aircraft Company
Torrance (C6) Facility
Resin Adsorption-Desorption Treatment System
Alternative 3
Figure 4-3

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Spent resin would be regenerated within the system using an inert gas. The organic laden inert gas stream would then be condensed to recover an organic compound-water mixture. This mixture would be sent to a recycling unit for solvent recovery.

Treated groundwater would be discharged to a sewer. Additional treatment for ketone removal will be required for disposal of treated groundwater to a surface drain, or reuse for groundwater recharge or industrial purposes. The ketone removal has been considered as an option in this feasibility study, and therefore, is not presented with the treatment alternative.

A flow schematic for the air stripping/resin adsorption-desorption alternative is presented in Figure 4-3.

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either a granular, soil-like material or a cohesive solid mass, depending on the amount of reagent added and the type and amount of waste.

- Lime-Based Processes

Lime-based processes are a minor variant of cement-based processes. The lime-based solidification/stabilization processes involve mixing lime and siliceous materials such as fly ash into the soil to produce a non-leachable product.
The solidification/stabilization techniques are historically more effective for inorganic compounds. However, specially formulated additives have been developed which enhance the stabilization of organic compounds, but their effectiveness has not been fully demonstrated. In addition, solidification/stabilization methods do not remove the hydrocarbons from the soil but merely reduce their mobility. The long-term stability of the solidified mass is difficult to predict. As a result, these technologies were not retained for further consideration.

Groundwater Remediation Technologies

Management. The management options include institutional controls to restrict future use and monitoring activities.

- Restrictions on Future Construction

Restrictions on future use (including human consumption) would be incorporated into the deed for the property in order to avoid future exposure to hydrocarbons.

- Migration Monitoring

Observation wells will be provided to monitor the migration of hydrocarbons in groundwater. This is necessary to prevent the migration of hydrocarbons to any surrounding aquifers or water bodies which have been identified for drinking water purposes.

However, the California Regional Water Quality Control Board has indicated the potential use of groundwater for human consumption in the future, necessitating the removal of hydrocarbons from groundwater. Hence the option of management was not retained for further consideration.

Containment. The containment options involve installation of physical barriers to minimize or prevent migration of hydrocarbons in groundwater. Since the volume and toxicity of hydrocarbons is not reduced by containment, long-term monitoring is typically required and additional remedial action may be required in the future. For this reason, containment options are typically combined with management/monitoring technologies and/or treatment or disposal technologies. The available containment options include:

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either a granular, soil-like material or a cohesive solid mass, depending on the amount of reagent added and the type and amount of waste.

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Lime-based processes are a minor variant of cement-based processes. The lime-based solidification/stabilization processes involve mixing lime and siliceous materials such as fly ash into the soil to produce a non-leachable product.
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- Vertical Barriers

Vertical barriers physically block the off-site migration of hydrocarbons in groundwater. Typical vertical barrier technologies include slurry walls and grout curtains, which form a cementitious barrier to groundwater movement, and sheet piles.

- Gradient Controls

Gradient controls include processes which modify the slope of the groundwater gradient to reduce or minimize off-site migration of hydrocarbons in groundwater. Barrier wells create cones of depression in the aquifer which contains hydrocarbons. Recharge wells inject treated groundwater into an aquifer to reverse an existing gradient and prevent inflow to a site. Gradient controls are usually considered an intrinsic element of groundwater pump and treat approaches.

The California Regional Water Quality Control Board has indicated the potential use of groundwater for human consumption in the future, necessitating the removal of hydrocarbons from groundwater. Chlorinated hydrocarbons dominate the organic compounds at the DAC Torrance Site. Biodegradation of chlorinated hydrocarbons by naturally occurring microorganisms has not been successfully demonstrated and the studies done to this effect are still in the experimental stage. Due to uncertainties in natural treatment through attenuation, dilution, and metabolism by microorganisms, containment technologies were not retained for further consideration.

In-situ Treatment. In-situ groundwater treatment options perform remediation of hydrocarbons in groundwater below ground rather than in above-ground reactors. Pumping and reinjection of groundwater may or may not be required. In-situ methods are potentially more effective than ex-situ methods because some in-situ methods may remediate soil-bound hydrocarbons below the water table in addition to dissolved hydrocarbons within the groundwater. For this reason, in-situ groundwater treatment may remediate sites in a shorter period of time than pump and treat techniques.

Physical Treatment

- Vapor Extraction

In-situ vapor extraction has been effective in remediation of hydrocarbons in groundwater as well as soil. However, due to the high solubility and vapor/water equilibrium conditions of certain compounds in water, vapor extraction will not be a very effective technique in removing all hydrocarbons from groundwater. This technology was not retained for further consideration.

- Air Stripping

In-situ air stripping involves volatilizing hydrocarbons from groundwater by injecting pressurized air into the soil below the water table. However, due to high solubility of certain compounds in water, air stripping will not be a very effective technique in removing all hydrocarbons from groundwater. In addition, the process of air stripping introduces air into groundwater and soil creating a region of high pressure. The air introduced could escape to nearby buildings, carrying potentially toxic hydrocarbons along with it, creating a potential hazard to human health. This technology was not retained for further consideration.

- Steam Stripping

In-situ steam stripping can be used to remediate hydrocarbon impacted groundwater, but as discussed earlier, the process has a very low commercial availability. Also, due to high solubility of certain compounds in water, steam stripping may not be a very effective technique in removing all hydrocarbons from groundwater. This technology was not retained for further consideration.

Chemical Treatment

- Chemical Hydrolysis

Chemical hydrolysis has been described previously (see In-Situ Soil Treatment description). The process has not been proven for in-situ groundwater treatment.

- Chemical Oxidation and Reduction

Chemical oxidation and reduction processes have been described previously (see In-Situ Soil Treatment description). The process has not been proven for in-situ groundwater treatment.

Due to lack of proven performance in effectively removing compounds of concern, these technologies were not retained for further consideration.

Biological Treatment

- Bioremediation

In-situ groundwater bioremediation uses microorganisms for degradation to remove hydrocarbons from groundwater. The basic concept involves controlling environmental conditions to enhance microbial activity and accelerate the degradation of hydrocarbons. The hydrocarbons are treated in-situ by extracting hydrocarbon groundwater downgradient of the hydrocarbon plume, adding oxygen, nutrients, and bacteria as necessary and re-injecting the solution into the aquifer upgradient of the hydrocarbon plume. In-situ groundwater bioremediation has been proven effective at over 100 petroleum hydrocarbon sites. However, bioremediation has not been successfully demonstrated for chlorinated hydrocarbons (e.g., 1,1-DCE, DCA, TCA, TCE, etc.) which dominate the hydrocarbon population at the Torrance site. Most of the studies done to date are either in the experimental stage or being tested currently in field situations. Due to this lack of sufficient information on biodegradation of chlorinated hydrocarbons, this technology was not retained for further consideration.

Ex-Situ Treatment. On-site or off-site groundwater treatment, collectively known as ex-situ methods, requires extraction of groundwater prior to treatment in above-ground reactors. The ex-situ methods have generally been demonstrated to a greater extent relative to in-situ methods, but ex-situ methods are typically more expensive.

Physical Treatment

- Carbon Adsorption

Granular activated carbon adsorption has been listed by the U.S. EPA as one of the Best Technologies Generally Available (BTGA) for removal of several volatile organic compounds (VOC) including aromatics, from water. It has been successfully used in full-scale treatment operations for removing greater than 99 percent of the hydrocarbons.

The groundwater containing hydrocarbons is passed through a column of GAC and the organic compounds are removed from the water by adsorption onto the carbon surface. Several factors controlling the degree of adsorption include: the specific surface area of the carbon, the nature of the hydrocarbon, the pH of the water, the temperature of the water, and the number of interacting compounds in the water. After a period of time, the carbon can no longer adsorb hydrocarbons from the water and it must be either regenerated or replaced with virgin carbon.

In addition to removing VOCs, it is also an effective method of removing most nonvolatile organics from water. Another advantage is that there are no associated air emission problems at the treatment site.

The two GAC contactor designs most commonly employed in the groundwater treatment industry are: (1) the pressurized contactor unit and (2) the gravity flow unit which is similar to the gravity media filter. For the application being evaluated, the gravity contactor has several advantages over the pressurized flow unit, including: ease of operation and the availability of either prefabricated or custom-design contactors. GAC adsorption is generally regarded as a safe and effective treatment process by the public. The disadvantages of carbon adsorption are that it is a relatively expensive method of treatment and it produces a hazardous material (RCRA hazardous waste under present conditions) which must be properly disposed of. The adsorption process merely transfers toxicants from the water to the carbon surface. Once breakthrough has been reached, the spent carbon (carbon that has reached its adsorption capacity) must either be regenerated on-site or transported off-site for regeneration or disposal by a licensed company. On-site regeneration is generally not economically feasible unless several thousand pounds of carbon are exhausted daily. This technology was retained for further consideration.

- Air Stripping

In the packed tower air stripping process, water is pumped to the top of the stripping tower and distributed evenly over the packing. The water flows downward through the packing to the bottom of the tower and into the storage reservoir. While the water is flowing downward, air is forced upward from the bottom of the tower, counter-current to the direction of the water flow. Because of their high vapor pressures and, in most cases, low solubilities (which corresponds with large Henry's constants), the volatile compounds in the water are transferred to the air as it flows past water.

The purpose of the packing is to provide more surface area for air and water interaction, thereby increasing the efficiency of mass transfer. The treated water flows by gravity through the tower for discharge and the hydrocarbon-laden air coming off the top of the tower passes to some form of vapor treatment. If GAC is used for vapor control, the VOCs are adsorbed onto the carbon surface. Because it has been shown that the adsorption capacity of the carbon is enhanced when the relative humidity of the airstream is reduced, the airstream leaving the stripping tower is heated in order to reduce its relative humidity to less than 50 percent.

Air stripping is an effective and reliable method of treatment for VOCs. The stripping tower can be designed to remove greater than 99 percent of the hydrocarbons from the water and a vapor control system can be designed to remove greater than 95 percent of the VOCs from the air stream. This technology was retained for further consideration.

- Steam Stripping

Steam stripping is similar to air stripping except that a stream of unsaturated steam is used in lieu of air to increase the water temperature and thus increase the volatilization of certain organic compounds that tend to slowly transfer to the vapor phase at ambient temperatures. This process is more effective in removing less volatile compounds than air stripping but the capital cost is higher since additional mechanical equipment (boilers, heat exchangers, etc.) is required. Operating costs are also much higher since the energy requirements are about 100 times that of an air stripping system.

Hydrocarbons removed from the groundwater may be recovered and recycled. This technology was retained for further consideration.

- Membrane Processes

Several membrane processes are available to remove organics from aqueous solutions. In general, the process of using semipermeable membranes to remove organics involves creating a driving force to make water pass through the membrane, leaving behind the organics and a portion of the water as a concentrate. The principal types of membrane processes used for organics removal are reverse osmosis, ultrafiltration, and air stripping.

In reverse osmosis, a differential pressure is applied across the membrane, causing water to flow from the stronger to the weaker solution and reducing the concentration of the stronger solution. In ultrafiltration, a much lower differential pressure is used and the nature of the membrane controls removal to a greater extent. Both of these processes will remove a large portion of the hydrocarbons found in the macromolecular size range as well as many of the dissolved organics which have very low solubility. These processes act to concentrate hydrocarbons into a smaller waste volume of brine which may require further treatment. In addition to the widely used technologies of reverse osmosis and ultrafiltration, stripping of hydrocarbons from water can be accomplished using modules containing microporous polypropylene hollow fiber membranes.

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Fouling can be expected to be a major problem with all of the membrane processes. Frequent membrane cleaning and flushing will be necessary. Extensive pretreatment of feed waters may be necessary to maintain fouling at acceptable levels. Additionally, the membrane processes will not be effective for removal of BTEX. This technology was not retained for further consideration.

Chemical Treatment

- Advanced Oxidation Process

Advanced Oxidation Processes (AOPs) are defined as those which involve the generation of hydroxyl (OH) radicals in sufficient quantity for water treatment by oxidation. Examples of AOPs include ozone/hydrogen peroxide, ozone/ultraviolet (UV) radiation, UV/hydrogen peroxide and ozone/UV/hydrogen peroxide. The significance of AOPs is that potentially they provide more powerful oxidation and at faster rates than can be achieved by a single oxidant. This allows oxidation of a variety of compounds which in the past have not been treatable with conventional oxidation processes.

Recent projects have demonstrated AOPs to be effective in treating groundwater containing certain priority organic compounds. The majority of this work has involved removal of chlorinated hydrocarbons such as TCE and PCE from drinking water wells. Complete oxidation has been achieved with end-products of carbon dioxide (CO_2), water, and halides (i.e., chloride, bromide, etc.).

Due to the potential savings that AOPs could have over conventional treatment technologies, any organics removal strategy should consider AOPs as a viable option. This technology was retained for further consideration.

Biological Treatment

- Activated Sludge

Activated sludge processes degrade organics in aqueous waste streams through the activity of aerobic microorganisms. Conventional activated sludge processes include an aeration tank, clarifier, sludge recycling system, and nutrient injection system. Modifications such as sequencing batch reactors can be added to the process to enhance performance. However, as previously discussed, biological methods have not been fully demonstrated for degrading chlorinated hydrocarbon, and so the technology was not retained for further consideration.

- Fixed Film Process

Fixed film processes cultivate aerobic microorganisms on fixed media. Waste streams containing organics are applied to the media where hydrocarbons are degraded by microorganisms. Aerobic fixed film processes include rotating biological contactors (RBCs), trickling filters, packed towers and submerged fixed film reactors. However, as previously discussed, biological methods have not been fully demonstrated for degrading

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chlorinated hydrocarbon hydrocarbons, and so the technology was not retained for further consideration.

- Land Application

Land application involves applying groundwater containing hydrocarbons onto the ground surface to allow degradation to occur naturally. Degradation occurs through biodegradation, volatilization, and oxidation by sunlight radiation. The process has been questioned for its applicability to treating hazardous wastes because of regulatory concerns and a lack of firm design criteria. This technology was not retained for further consideration.

- Anaerobic Process

Anaerobic processes use anaerobic microorganisms to digest organics and convert them from complex molecules to carbon dioxide and methane. Anaerobic digestion occurs in reactors designed to cultivate microbes and enhance contact between microbes and waste materials. However, the process has not been sufficiently demonstrated for chlorinated hydrocarbons, and so the technology was not retained for further consideration.

<u>Biophysical Treatment</u>

- PACT Process

The PACT Process involves the controlled addition of powdered activated carbon (PAC) to the aeration basin of a biological wastewater-treatment system to enhance the degradation and removal of organic materials. The process is applicable to aqueous waste streams containing dilute concentrations of organics. Due to the concentration of hydrocarbons in the groundwater, the technology was not retained for further consideration.

- GAC Fluidized Bed

Fluidized bed biotreatment is an emerging technology which uses fixed-film immobilization, fluidization, and recycle of biomass to achieve greater biomass concentrations and solids retention time compared to conventional biological treatment systems. The fluidized bed process potentially allows improved biotreatment at reduced liquid contact times. Fluidized bed systems may be operated under aerobic or anaerobic conditions and fluid bed media typically consists of either inert sand or granular activated carbon (GAC). As previously mentioned, biological processes have not been fully demonstrated for chlorinated hydrocarbons, and so the technology was not retained for further consideration.

Discharge. The option of discharge always exists for groundwater pump and treat. Discharge can be performed either on untreated groundwater or treated groundwater.

Treated Groundwater

- Surface Water Discharge

Treated groundwater can be discharged into wetlands, lakes, or streams provided effluent water quality meets applicable state and federal regulatory standards. The National Pollution Discharge Elimination System (NPDES) establishes specific permit requirements covering industrial discharges into surface water bodies. The treated groundwater will be required to meet the state MCLs for drinking water standards prior to use of this option. Additional groundwater treatment for ketone removal will be required to meet the state MCLs for drinking water requirement. The option was retained for further consideration.

- Groundwater Recharge

Treated effluent from remediation processes can be returned to the aquifer if effluent water quality meets applicable state and federal regulatory standards. Based on the "non-degradation" policy set forth by the RWQCB, the treated groundwater will be required to meet the state MCLs for drinking water standards before it can be utilized for groundwater recharge. Additional groundwater treatment for ketone removal will be required in order to meet the state MCLs for drinking water standards. The option was retained for further consideration.

- Industrial Process Use

Treated liquid wastes can sometimes be incorporated into industrial processes. There is a possibility that the treated groundwater could be reused as process water within the DAC operations. However, the presence of ketones in the treated groundwater could be a hindrance for industrial use purposes. Further treatment for removal of ketones will be required prior to use of treated groundwater for industrial use purpose. The option was retained for further consideration.

- Discharge to a Sewer

Treated groundwater can be discharged to a sewer provided it satisfies the criteria established by the County Sanitation Districts of Los Angeles County (CSDLAC). Currently, CSDLAC has a discharge limit of 1.0 mg/l total toxic organics (TTO). The treated groundwater is anticipated to contain less than 1.0 mg/l TTO, except for ketones, which are currently not regulated. Therefore, no additional treatment for ketone removal is required with this discharge option. This option will be considered as the primary option for discharge of treated groundwater in this feasibility study.

Untreated Groundwater

- RCRA Treatment Facility

Extracted groundwater can be containerized and transported to RCRA treatment facilities. However, RCRA treatment facilities have discharge limits much lower than the anticipated concentrations of hydrocarbons in groundwater at the Torrance site. It is anticipated that groundwater extracted from the Torrance site will not be acceptable to the existing RCRA treatment facilities. The option was not retained for further consideration.

Ketone Removal Technologies (Option)

The ketones (MEK and MIBK) are currently not regulated by the CSDLAC for discharge to a sanitary sewer. However, in order to use the option of surface water discharge, groundwater recharge or industrial reuse processes, additional groundwater treatment will be required for alleviation of ketone levels in the groundwater. This section presents the technologies available for removal of ketone from the groundwater after other major hydrocarbons, specifically the chlorinated hydrocarbons, have been removed.

- Rotating Biological Contactor

The rotating biological contactor (RBC) is a fixed-film process in which microörganisms are cultivated on fixed media under aerobic conditions. Waste streams containing organics are applied to the media where hydrocarbons are degraded by microorganisms. Since ketones are relatively amenable to biodegradation, RBCs have been successfully used to biodegrade ketones at several sites across the country. RBCs provide ease of operation with little maintenance and are flexible to varying influent loading conditions. This technology was retained for further consideration.

- Activated Carbon Fluidized Bed Reactor

A fluidized bed reactor consists of an activated carbon bed on which microbial growth occurs. The fluidized bed offers a multi-purpose treatment system capable of handling VOCs and aromatics. The process involves adsorption of VOCs and aromatics on to the activated carbon surface. The adsorbed organics are subsequently biodegraded through microbial processes, producing byproducts such as carbon dioxide, water and chloride ions. Fluidized bed reactors have not proven to be very effective in presence of chlorinated hydrocarbons. Laboratory studies indicate low carbon adsorption efficiencies resulting in early break-through from the reactor. Further, pH depression as a result of chloride ion generation during microbial biodegradation process hinders further growth of microorganisms on the carbon surface. The technology was not retained for further consideration.

- Steam Stripping with Distillation

This technology involves steam stripping of groundwater to transfer ketones from the liquid phase to the steam phase in a steam stripping tower. The ketone laden steam is subsequently condensed and purified to extract ketones. The process involves very high capital cost and has not been proven cost-effective at relatively low concentrations of ketones. The option was not retained for further consideration.

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Vapor Phase Treatment Technologies

The soil-vapors from the soil-vapor extraction (SVE) system, and any off-gas from the groundwater treatment system (i.e., an air stripping tower) will contain VOCs. The South Coast Air Quality Management District (SCAQMD) severely restricts the amount of VOCs that can be emitted to the atmosphere. Consequently, the soil-vapors and any off-gas from a groundwater treatment system will require pretreatment before being emitted to the atmosphere. The following subsection describes remedial technologies available for vapor treatment.

Physical Treatment

- Carbon Adsorption

Carbon adsorption removes most organic compounds from vapors through the adsorption process. Carbon adsorption is used to treat single-phase aqueous wastes with a high boiling point and high molecular weight, and volatile organics in gaseous mixtures. It is widely used to control vapors at groundwater treatment facilities.

GAC systems with very high carbon usage rates are not economical. In these situations, on-site regeneration of carbon may be required to keep the system cost effective. The most common type of media used for regeneration of spent carbon is steam. In this type of system, the hydrocarbons in the air stream are passed through one of two carbon absorbers operating in parallel. While one adsorber is on-line the second is being regenerated by passing steam at about 220F through it. The organic laden steam is then cooled in a condenser and the condensate collected for disposal or solvent recovery. The steam cycle is followed by a dry air cycle to remove moisture from the carbon surface which could otherwise adversely effect the adsorption capacity of the carbon. This technology was retained for further consideration.

- Resin Adsorption-Desorption Process

The resin adsorption-desorption process is a proprietary vapor phase treatment system being offered by Purus, Inc (PADRE™). The system is particularly applicable to hydrocarbons and chlorinated solvents in the vapor phase. In this system, hydrocarbons in the vapor phase are transferred onto a concentrator, consisting of three resin adsorption beds. The resin is a proprietary material which has a high affinity for adsorbing hydrocarbons, but is easily regenerated using an inert gas. At any time, two beds are on-line while the third bed is undergoing a desorption cycle. The relatively short desorption cycle allows for minimum operating cost. During the desorption, the hydrocarbons are stripped from the resin beds using an inert gas and then condensed to yield hydrocarbon and water mixture. This mixture is stored in a special containment system and sent to a recycling facility for solvent recovery.

The system offers the advantages of operational simplicity and minimum capital and operating cost when compared with other vapor phase treatment systems of similar capacity. Savings in operating cost stem from the fact that the adsorbent has a very long operating life and does not require frequent changes as is the case with activated carbon.

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Further, the process capability to handle high humidity vapors eliminates or reduces the energy requirements associated with decreasing the relative humidity of the vapor stream as with GAC systems. Although this system has yet not been fully proven in this type of application, it has been used extensively in the chemical process industry for recovery of solvents. This technology was retained for further consideration.

- Condensation

Condensers remove volatile hydrocarbons in the vapor phase by liquefying them with a change of temperature or pressure. The process is most applicable to vapors containing high concentrations of organics. However the process has not proven very effective for moisture laden vapors. The water content of vapors tends to freeze in the condensation unit, necessitating downtime of the system. Removal efficiencies are typically low. This technology was not retained for further consideration.

<u>Chemical Treatment</u>

- Advanced Oxidation Processes

As discussed earlier, the key to organic destruction in advanced oxidation processes (AOP) is the hydroxyl radical. Pathways to forming this reactive intermediate are: to react UV radiation with ozone, UV radiation with hydrogen peroxide, or hydrogen peroxide with ozone. However, in water, a number of naturally occurring compounds act as scavengers which remove the hydroxyl free radicals from solution before they can react with the VOC. Another problem with liquid-phase AOP is that the reaction to form the free radicals where ozone is used is limited by the transfer rate of ozone from the gas phase to the water phase. To avoid both the scavenger and the rate of transfer limitations, vapor-phase AOPs have recently been developed. These processes are presently in the experimental stages of development. This technology was not retained for further consideration.

- Catalytic Oxidation Process

The catalytic oxidation process involves thermal incineration of the organic contents in presence of a catalyst. In this process, the air stream is first preheated by passing it through a primary heat exchanger and into the burner chamber. The preheated air is then uniformly distributed over a catalyst matrix where the hydrocarbon destruction takes place. The destruction process is an exothermic reaction whereby the hydrocarbons or chlorinated hydrocarbons are converted to by-products such as carbon dioxide, water and hydrochloric acid. Upon exiting the catalytic chamber, the air stream is passed through a caustic scrubber where hydrochloric acid is converted to a chloride solution. Prior to exhausting the clean air to the atmosphere, it is passed through another heat exchanger to transfer heat energy back to the incoming stream, thus minimizing the system energy costs.

The presence of a catalyst allows for lower operating temperatures and consequently lower operating cost. The catalytic system operates at about 600F compared to temperatures of 1200-1400F normally required in a thermal incineration process.

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Recent advances in catalytic oxidation process have led to a development of special catalysts that are not poisoned by chlorinated solvents, thus increasing the operating life and efficiency of the catalyst and reducing the operating cost. This technology was retained for further consideration.

SUMMARY

Table 3-2 provides the summarized results of initial screening of potential technologies and process options for remediation of soil and groundwater hydrocarbons at the Torrance (C6) facility. The identified applicable technologies will be carried forward for further screening based on effectiveness, implementability and a cost factor.

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TABLE 3-2

RESULTS OF REMEDIATION TECHNOLOGY SCREENING

Technology	Screening Criteria: Effective	Screening Criteria: Demonstrated Performance	Screening Criteria: Commercially Available	Potential Applicability
SOIL RESPONSE ACTION				
NO ACTION	No	-	-	Does not mitigate potential for exposure via migration of vapors or future excavation.
MANAGEMENT				
Restrictions on Future Construction	Yes	-	-	Does not mitigate potential for exposure via migration of vapors or future excavation.
Gas Monitoring	Yes	-	-	Does not mitigate potential for exposure via migration of vapors or future excavation.
CONTAINMENT				
Capping	Yes	Yes	Yes	Asphalt cap already exists. Does not minimize migration of hydrocarbons from unsaturated to saturated zone.
Surface Controls	Yes	Yes	Yes	Asphalt cap already exists. Does not minimize migration of hydrocarbons from unsaturated to saturated zone.
Horizontal Barriers	Yes	No	No	Asphalt cap already exists. Does not minimize migration of hydrocarbons from unsaturated to saturated zone.
Vertical Barriers	Yes	Yes	Yes	Long term effectiveness not known.
IN-SITU TREATMENT				
Physical Treatment				
Soil Flushing	No	No	Yes	Not effective for silty soils identified at the site.
Soil Vapor Extraction	Yes	Yes	Yes	Applicable.
Steam Stripping	Yes	No	No	Very limited commercial availability.
Radio Frequency Heating	Yes	No	Yes	Developed at experimental stage only.

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TABLE 3-2 (continued)

RESULTS OF REMEDIATION TECHNOLOGY SCREENING

Technology	Screening Criteria: Effective	Screening Criteria: Demonstrated Performance	Screening Criteria: Commercially Available	Potential Applicability
Chemical Degradation				
Ultraviolet Photolysis	No	No	No	Not effective for subsurface soils.
Chemical Hydrolysis	No	No	No	Not effective for chlorinated hydrocarbons.
Chemical Oxidation	No	No	No	Not demonstrated for in-situ applications.
Biological Degradation				
Liquid Phase Bioremediation	No	No	Yes	Not demonstrated for chlorinated hydrocarbons.
Bioventing	No	No	Yes	Not demonstrated for chlorinated hydrocarbons.
Solidification/Stabilization				
Cement-Based Process	Yes	No	Yes	Not fully demonstrated for organic compounds.
Lime-Based Process	Yes	No	Yes	Not fully demonstrated for organic compounds.
EX-SITU TREATMENT				
Physical Treatment				
Solvent Extraction	Yes	No	Yes	Excavation of soil is not practical at the Torrance (C6) Facility.
Soil Washing	Yes	Yes	Yes	Excavation of soil is not practical at the Torrance (C6) Facility.
Land Spreading	No	No	Yes	Excavation of soil is not practical at the Torrance (C6) Facility.
Soil Vapor Extraction	Yes	Yes	Yes	Excavation of soil is not practical at the Torrance (C6) Facility.
Chemical Treatment				
Ultraviolet Photolysis	No	No	Yes	Not demonstrated for soil remediation.
Chemical Hydrolysis	No	No	Yes	Not demonstrated for soil remediation.
Chemical Oxidation	No	No	Yes	Not demonstrated for soil remediation.

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TABLE 3-2 (continued)

RESULTS OF REMEDIATION TECHNOLOGY SCREENING

Technology	Screening Criteria: Effective	Screening Criteria: Demonstrated Performance	Screening Criteria: Commercially Available	Potential Applicability
Biological Treatment				
Landfarming	Yes	Yes	Yes	Excavation of soil is not practical at the Torrance (C6) Facility.
Compost Heap	Yes	Yes	Yes	Excavation of soil is not practical at the Torrance (C6) Facility.
Slurry Bioreactor	Yes	Yes	Yes	Excavation of soil is not practical at the Torrance (C6) Facility.
Solidification/Stabilization				
Cement-Based Process	Yes	No	Yes	Not fully demonstrated for organic compounds.
Lime-Based Process	Yes	No	Yes	Not fully demonstrated for organic compounds.
Thermoplastic Solidification	Yes	Yes	Yes	Excavation of soil is not practical at the Torrance (C6) Facility.
GROUNDWATER RESPONSE ACTION				
NO ACTION	No	-	-	Does not mitigate the problem or meet the non-degradation policy.
MANAGEMENT				
Restrictions on Future Construction	Yes	-	-	Does not mitigate the problem or meet the non-degradation policy.
Migration Monitoring	Yes	-	-	Does not mitigate the problem or meet the non-degradation policy.
CONTAINMENT				
Vertical Barriers	No	Yes	Yes	Does not mitigate the problem or meet the non-degradation policy.
Gradient Controls	Yes	Yes	Yes	Does not mitigate the problem or meet the non-degradation policy.
IN-SITU TREATMENT				
Physical Treatment				
Vapor Extraction	No	No	Yes	Not effective for highly water soluble compounds.
Air Stripping	No	No	No	Not effective for highly water soluble compounds.
Steam Stripping	Yes	Yes	No	Very limited commercial availability.

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TABLE 3-2 (continued)

RESULTS OF REMEDIATION TECHNOLOGY SCREENING

Technology	Screening Criteria			Potential Applicability
	Effective	Demonstrated Performance	Commercially Available	
Chemical Treatment				
Chemical Hydrolysis	No	No	No	Not demonstrated for in-situ applications.
Chemical Oxidation	No	No	No	Not demonstrated for in-situ applications.
Biological Treatment				
Bioremediation	No	No	Yes	Not fully demonstrated for chlorinated hydrocarbons.
EX-SITU TREATMENT				
Physical Treatment				
Carbon Adsorption	Yes	Yes	Yes	Applicable.
Air Stripping	Yes	Yes	Yes	Applicable.
Steam Stripping	Yes	Yes	Yes	Applicable.
Membrane Processes	No	No	Yes	Not effective for all hydrocarbons at the site.
Chemical Treatment				
Advanced Oxidation Process	Yes	Yes	Yes	Applicable.
Biological Treatment				
Activated Sludge	No	No	Yes	Not demonstrated for chlorinated hydrocarbons.
Fixed Film Process	No	No	Yes	Not demonstrated for chlorinated hydrocarbons.
Land Application	No	No	Yes	Not demonstrated for chlorinated hydrocarbons.
Anaerobic Process	No	No	Yes	Not demonstrated for chlorinated hydrocarbons.
Biophysical Treatment				
PACT Process	No	No	Yes	Not demonstrated for chlorinated hydrocarbons.
GAC Fluidized Bed	No	No	Yes	Not demonstrated for chlorinated hydrocarbons.

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TABLE 3-2 (continued)

RESULTS OF REMEDIATION TECHNOLOGY SCREENING

Technology	Screening Criteria			Potential Applicability
	Effective	Demonstrated Performance	Commercially Available	
KETONE REMOVAL (OPTION)				
Fixed-film Process	Yes	Yes	Yes	Applicable
Fluidized Bed Process	No	No	Yes	Not demonstrated in the presence of chlorinated hydrocarbons.
Steam Stripping with Distillation	Yes	No	No	Not applicable for small systems.
DISCHARGE				
Treated Groundwater				
Surface Water Discharge	Yes	-	-	Applicable if ketone removal option is used.
Groundwater Recharge	Yes	-	-	Applicable if ketone removal option is used.
Industrial Process Use	Yes	-	-	Applicable if ketone removal option is used.
Discharge to a Sewer	Yes	-	-	Applicable.
Untreated Groundwater				
RCRA Treatment Facility	Yes	-	-	RCRA discharge criteria limitations exceeded.
Discharge to POTW	Yes	-	-	POTW discharge criteria limitations exceeded.
VAPOR PHASE TREATMENT				
Physical Treatment				
Carbon Adsorption	Yes	Yes	Yes	Applicable.
Condensation	No	No	Yes	Not effective for high moisture content SVE vapor streams
Resin Adsorption-Desorption System	Yes	No	Yes	Applicable.
Chemical Treatment				
Advanced Oxidation Process	Yes	No	Yes	Developed at experimental stage only.
Catalytic Oxidation Process	Yes	Yes	Yes	Applicable.

Chapter 4

CHAPTER 4

DEVELOPMENT OF REMEDIATION ALTERNATIVES

SCREENING OF TECHNOLOGIES

The main objective of this feasibility study is to evaluate remedial alternatives for soil and groundwater at the DAC Torrance Facility which will assure adequate protection of human health and the environment. General response actions for hydrocarbon mitigation at the site include options for management, containment, treatment and/or disposal of groundwater and unsaturated zone soil. In Chapter 3, candidate remedial technologies that may be applicable for the management, containment, treatment or disposal of the hydrocarbons were identified. These remedial technologies were screened according to site-specific criteria to determine which of the technologies were best suited for the site conditions and cleanup objectives. Table 4-1 provides a list of the remedial technologies determined to be applicable for remediation of soil and groundwater bound hydrocarbons at the Torrance (C6) Facility.

Table 4-1 suggests that for soil management and in-situ treatment only one candidate technology was retained for each option after initial screening, indicating that only a single technology was considered feasible for each of these options. However, several technologies passed the initial screening criteria for groundwater treatment and vapor phase treatment. These technologies were further screened based on the following criteria:

- Performance
- Reliability
- Implementability
- Safety
- Environmental impacts, and
- Costs

A separate screening was performed for groundwater and vapor treatment technologies. Tables 4-2 and 4-3 summarize the screening process for groundwater and vapor treatment, respectively.

From Table 4-2, it can be noted that all identified technologies are capable of treating the groundwater to meet the cleanup objectives stated in Chapter 2. All identified technologies are established technologies offering the same degree of reliability and with similar implementability requirements. The air stripping process has low O&M requirements compared to other technologies, but will require further treatment downstream in order to meet the SCAQMD emissions limit. The GAC system will produce hazardous waste requiring disposal or regeneration. Therefore, it can be concluded that all identified technologies will accomplish abatement of hydrocarbons with essentially the same effectiveness and implementability. In a situation like this, the cost of implementing a remedial technology becomes an important element in selection of a final candidate remedial technology.

TABLE 4-1

SUMMARY OF APPLICABLE REMEDIAL TECHNOLOGIES

General Response Action	Technology
Soil Response Action	
Management	Gas Monitoring
In-situ Treatment	Soil-Vapor Extraction System
Groundwater Response Action	
Ex-situ Treatment	Carbon Adsorption - Off-site Regenerable Air Stripping Steam Stripping Advanced Oxidation Process
Groundwater Discharge	Discharge to a Sanitary Sewer Surface Water Discharge (Option)* Groundwater Recharge (Option)* Industrial Water Use (Option)*
Ketone Removal (Option)*	Rotating Biological Contactor
Vapor phase Treatment	Carbon Adsorption - Off-site Regeneration Carbon Adsorption - On-site Regeneration Adsorption-Desorption Process Catalytic Oxidation Process

* = Ketone removal will be required to use these options

Table 4-2
SUMMARY OF TECHNOLOGY SCREENING
GROUNDWATER REMEDIATION

Criteria	Air Stripping	Steam Stripping	Advanced Oxidation	Carbon Adsorption
PERFORMANCE				
Effectiveness at meeting cleanup objectives	Effective removal of volatile and semivolatile organics	Effective removal of volatile and many semivolatile organics	Effective removal of volatile and many semivolatile organics	Effective removal of volatile and semivolatile organics
RELIABILITY				
Process Complexity	Very simple	Somewhat complex	Complex	Relatively simple
O & M requirements	Low	Moderate	Moderate to high	Low to moderate
Process Flexibility	Good flexibility to handle variable influent	Good flexibility to handle variable influent	Little flexibility to handle variable influent	Good flexibility to handle variable influent
Probability of failure or shutdown	Process is very stable	More likely that shutdowns could be necessary to maintain the system	Very likely that incomplete treatment could occur during shock loads	Process is very stable
IMPLEMENTATION				
Contractibility	Easy	Fairly easy	Complex	Easy
Time to construct	5-6 months	6-8 months	8-10 months	5-6 months
SAFETY	Operators could be exposed to VOC emissions unless proper precautions are taken or offgases are collected	Operators could be exposed to VOC emissions unless proper precautions are taken or offgases are collected	Most chemical oxidants require special storage and handling	None

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Table 4-2 (Continued)
SUMMARY OF TECHNOLOGY SCREENING
GROUNDWATER REMEDIATION

Criteria	Air Stripping	Steam Stripping	Advanced Oxidation	Carbon Adsorption
ENVIRONMENTAL IMPACTS				
Generation of noise and odors	Minor noise associated with blowers. Odors maybe generated if biofouling occurs	Some noise associated with pumps and steam system. Odors may be generated if offgases are not collected.	Minor noise associated with pumps	Minor noise associated with pumps. Odors maybe generated if biofouling occurs
Air pollution	VOCs will be emitted if offgases are not collected and treated	VOCs will be emitted if offgases are not collected and treated	None	None
Generation of Residuals	The liquid phase treatment does not generate residuals, but the vapor phase treatment system may depending on the technology selected.	Process generates a concentrated organic mixture which would need to be recycled or disposed	None	The spent carbon would be considered hazardous waste and would require proper regeneration or disposal
COSTS (Liquid Phase Treatment Only)				
Capital	Low	High	Moderate to high	Low
O & M	Low	Moderate to high	Very high	Very high

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Table 4-3
SUMMARY OF TECHNOLOGY SCREENING
VAPOR TREATMENT

Criteria	G A C (Off - site Regeneration)	G A C (On - site Regeneration)	Catalytic Oxidation	Resin Adsorption Desorption
PERFORMANCE				
Effectiveness at meeting discharge standards	Effective removal of chlorinated hydrocarbons and aromatics	Effective removal of chlorinated hydrocarbons and aromatics	Effective removal of chlorinated hydrocarbons and aromatics	Effective removal of chlorinated hydrocarbons and aromatics
RELIABILITY				
Process Complexity	Relatively simple	Somewhat complex	Somewhat complex	Relatively simple
O & M requirements	Low	Moderate	Moderate	Moderate
Process Flexibility	Good flexibility to handle variable influent	Good flexibility to handle variable influent	Less flexibility to handle variable influent	Good flexibility to handle variable influent
Probability of failure or shutdown	Process is very stable	Process is very stable	More likely that incomplete treatment could occur during shock loads	Process is very stable
IMPLEMENTATION				
Contractibility	Easy	Relatively easy	Relatively easy	Relatively easy
Time to construct	5-6 months	7-9 months	6-8 months	8-10 months
SAFETY	Relatively safe	Relatively safe	Relatively safe	Relatively safe

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Table 4-3 (Continued)
SUMMARY OF TECHNOLOGY SCREENING
VAPOR TREATMENT

Criteria	G A C (Off - site Regeneration)	G A C (On - site Regeneration)	Catalytic Oxidation	Resin Adsorption Desorption
ENVIRONMENTAL IMPACTS				
Generation of noise	Minor noise associated with pumps	Minor noise associated with pumps and steam system.	Minor noise associated with pumps	Minor noise associated with pumps
Generation of Residuals	The spent carbon would be considered hazardous waste and would require proper disposal or regeneration	The condensate would be considered hazardous waste and would require proper disposal	Process will generate a small waste stream suitable for discharge to sewer	Process generates a concentrated organic mixture which would need to be recycled or disposed
COSTS (Vapor Phase Treatment Only)				
Capital	Low	High	Moderate to high	Moderate
O & M	Very high	Moderate	Moderate	Low

From Table 4-3, a similar conclusion can be drawn about the identified vapor treatment technologies. Consequently, the cost to implement the remedial technology becomes an important element.

The preliminary cost estimates were developed for each of the groundwater and vapor phase treatment technologies identified in Tables 4-2 and 4-3. The cost estimates were based on vendor information and experience in developing cost estimates for similar projects. In order to compare different technologies capable of achieving the cleanup objectives, several assumptions had to be incorporated in the cost analysis:

Groundwater Treatment

- The total flowrate from all extraction wells was assumed to be 100 gallons per minute (gpm).

- The weighted average concentration of each compound was assumed as the influent concentration to be treated.

- The groundwater discharge criteria was based on 1.0 mg/l total toxic organics, except ketones. The ketones are currently not regulated under the CSDLAC discharge criteria which has been considered as the primary discharge option. In order to utilize other discharge options, specifically surface water discharge or the groundwater recharge or industrial water reuse, additional groundwater treatment for ketone removal will be required in order to meet the NPDES permit requirements. At present, no state regulations exist for ketone levels in the discharge waters. A total ketone concentration of 1.0 mg/l has been established for treatment purpose in this feasibility study. The cost for ketone removal will be the same for all alternatives and has not been included in the alternatives cost estimate.

- The capital investment and operating cost for each technology were based on the assumption of complete groundwater treatment and hydrocarbon destruction/disposal through each technology (e.g., air stripping would require an off-gas treatment system, such as a catalytic oxidation process followed by a caustic scrubber. So the capital and operating cost of an off-gas treatment system had to be added to the capital and operating cost of an air stripper, respectively).

Vapor Phase Treatment

- Soil-vapor extraction system was assumed to produce 650 scfm flowrate.

- The total flowrate of air stripper off-gas was assumed to be 800 scfm.

- Each technology was evaluated for treatment of SVE system alone and SVE system and air stripper off-gas flowrate combined.

- The discharge criteria for treated air were based on the South Coast Air Quality Management District (SCAQMD) guidelines.

- The operating life of the SVE system was assumed to be five (5) years.

- The capital investment and operating cost for each technology were based on the assumption of complete soil-vapor treatment and hydrocarbon destruction/disposal through each technology (e.g., catalytic oxidation process would require a caustic scrubber for hydrochloric acid generated during the process. So the capital and operating cost of a caustic scrubber had to be added on to the capital and operating cost of a catalytic oxidation system, respectively).

With the above mentioned assumptions, the capital investment and the annual operating cost of various soil remediation technologies along with a 5-year present worth analysis is presented in Table 4-4. The cost estimates have been developed for the SVE system alone and for a combined SVE and air stripper off-gas system. This will facilitate a better cost comparison of different alternatives at a later stage. A similar analysis for groundwater treatment technologies is presented in Table 4-5. The groundwater treatment system is expected to have a longer operating life compared to a vapor phase treatment system, and thus the present worth analysis has been performed for up to 30 years.

Based on cost estimates presented in Tables 4-4 and 4-5, the treatment technologies considered to be cost-effective for groundwater and unsaturated zone soil remediation are shown in Table 4-6. These candidate remedial technologies were assembled into specific response alternatives presented below. These alternatives represent combinations of the remedial technologies that could be employed as overall control measures for groundwater and unsaturated zone soil remediation.

DEVELOPMENT AND DESCRIPTION OF REMEDIATION ALTERNATIVES

The technology screening in Chapter 3 identified a soil-vapor extraction system to be the only technically feasible soil response action capable of mitigating the hydrocarbons at the site. This treatment system has been included in all alternatives presented. Similarly for the groundwater response action, pump and treat is the only groundwater treatment technology that could effectively meet the cleanup objectives. For the groundwater flowrate established for the extraction (pumping) system, an air stripper was found to be the most attractive treatment technology, and is included in all of the alternatives presented. In each alternative, off-gas from the air stripper has been combined with the SVE system for vapor phase treatment. A fixed-film bioreactor, such as a RBC, is considered the most feasible option for removal of ketones from the groundwater to cleanup objectives if the discharge options of surface water, groundwater recharge or industrial water use are considered. Therefore, a fixed-film bioreactor will be considered for the ketone removal option with each alternative. The specific response alternatives, therefore, differ primarily in the technologies considered for vapor phase treatment and disposal of the hydrocarbons generated during the treatment process.

Based on previous technology screenings, three alternatives were developed for groundwater and unsaturated zone soil remediation, as presented in this section. Detailed analysis of

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TABLE 4-4

ECONOMIC EVALUATION OF VAPOR PHASE TREATMENT TECHNOLOGIES

Technology	SVE System			Combined SVE System and Air Stripper Off-gas		
	Capital Investment	Annual Cost	5 Year Present Worth	Capital Investment	Annual Cost	5 Year Present Worth
GAC with Off-site Regeneration	$120,000	$495,000	$1,751,575	$120,000	$702,000	$2,429,678
GAC with On-site Regeneration Recycling cost	$265,000	$62,000	$465,458	$390,000	$86,000	$669,914
Catalytic Oxidation Process Scrubber for HCl treatment Chemical storage Heat exchanger	$175,000	$60,000	$402,460	$240,000	$87,000	$526,587
Resin Adsorbtion-Desorption Process (PADRE) Recycling cost	$115,000	$40,000	$234,938	$175,000	$56,000	$349,830

1. Steam was assumed to be available on-site. Cost for steam generation reflects only the associated fuel cost.
2. 100 percent hydrocarbons recycled.
3. Present worth analysis based on 10 percent annual compound interest.
4. Capital investment is for vapor phase treatment equipment only. Annual cost is for hydrocarbon treatment only.
5. Assuming air compressor is available on-site.
6. Annual cost is for Year-1. Annual cost for subsequent years will be lower due to decreasing hydrocarbon concentration.

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TABLE 4-5

ECONOMIC EVALUATION OF GROUNDWATER TREATMENT TECHNOLOGIES

Alternative	Capital Investment	Annual Cost	5 Year Present Worth	10 Year Present Worth	20 Year Present Worth	30 Year Present Worth
GAC with Off-site Regeneration	$120,000	$740,000	$2,925,340	$4,666,560	$6,420,360	$7,095,980
Air Stripping Off-gas treatment by resin adsorption-desorption process Chemical storage Anti-scaling agent	$215,000	$63,000	$453,833	$602,072	$751,382	$808,901
Steam Stripping Organic Phase Separator Recycling cost	$510,000	$135,000	$1,021,785	$1,339,440	$1,659,390	$1,782,645
Advanced Oxidation Process	$510,000	$270,000	$1,533,570	$2,168,880	$2,808,780	$3,055,290

1. Steam was assumed to be available on-site. Cost for steam generation reflects only the associated fuel cost.
2. 100 percent hydrocarbons recycled.
3. Present worth analysis based on 10 percent annual compound interest.
4. Capital investment is for groundwater treatment equipment only. Annual cost is for hydrocarbon treatment only.
5. Assuming air compressor is available on-site.
6. Annual cost is for Year-1. Annual cost for subsequent years will be lower due to decreasing hydrocarbon concentration.

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TABLE 4-6

SUMMARY OF COST EFFECTIVE REMEDIAL TECHNOLOGIES

General Response Action	Technology
Soil Response Action	
Management	Gas Monitoring
In-situ Treatment	Soil-Vapor Extraction System
Groundwater Response Action	
Ex-situ Treatment	Air Stripping
Groundwater Discharge	Discharge to a Sanitary Sewer Surface Water Discharge (Option)* Groundwater Recharge (Option)* Industrial Water Use (Option)*
Ketone Removal (Option)*	Fixed-Film Bioreactor
Vapor Phase Treatment	Carbon Adsorption - On-site Regeneration Adsorption-Desorption Process Catalytic Oxidation Process

* = Ketone removal will be required to use these options

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the alternatives is presented in Chapter 5 of this report and will form the basis for a comparative evaluation of the specific response alternatives.

Alternative 1: Groundwater Treatment with Air Stripper/Vapor Phase Treatment with Carbon Adsorption with On-site Regeneration

This alternative would include the following processes.

- Soil-Vapor Extraction
- Carbon Adsorption of Vapor Phase
- Groundwater Extraction
- Groundwater Treatment with Air Stripper
- Off-gas Treatment by Carbon Adsorption
- Recycling of Organic Compounds
- Disposal of Treated Groundwater to a Sewer
- Discharge of Treated Air Stream
- Ketone Removal with a Rotating Biological Contactor (for other disposal options)

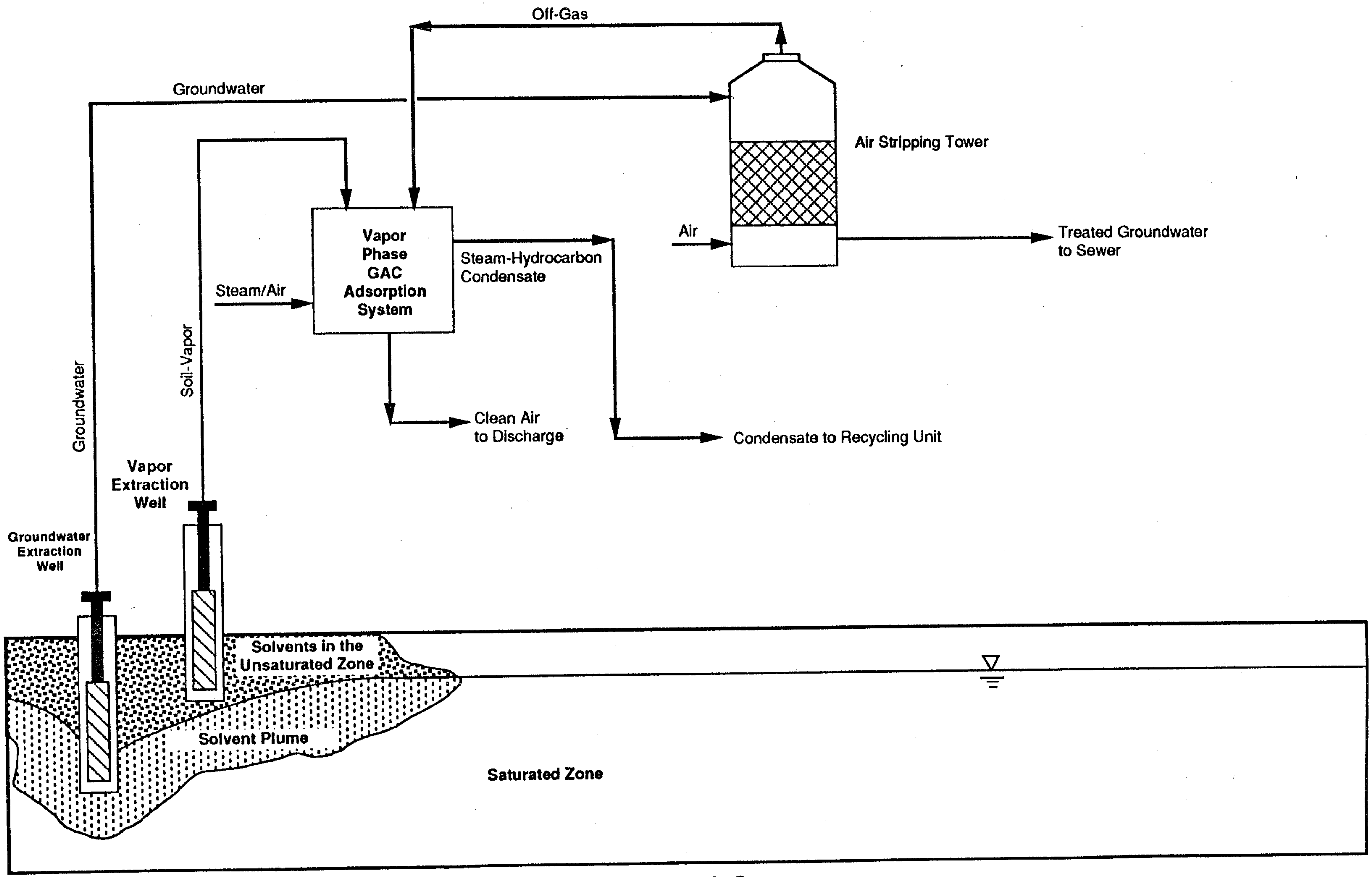
Alternative 1 would reduce the level of hydrocarbons in the unsaturated zone by inducing a flow of air through the soil to vaporize the volatile hydrocarbons. Hydrocarbons would be removed from the resulting air stream using an activated-carbon system. A vapor extraction pilot test will be required to determine the actual radius of influence which can be achieved by each vapor well.

Groundwater extraction wells would pump groundwater to the surface for treatment. Pumping groundwater from the aquifer gradually removes the hydrocarbons from the aquifer. An additional pump test needs to be performed prior to implementing this alternative to verify that adequate groundwater recovery rates can be achieved with each well.

Counter-flow, packed tower air stripping would be employed for groundwater treatment. Air stripping will remove 99 percent of the aromatics and chlorinated hydrocarbons and transfer them to the air stream. The majority of ketones (MEK and MIBK) will remain in the liquid stream. The vapor stream would then pass through an activated-carbon system where the hydrocarbons would be adsorbed on the carbon surface. The treated air would be emitted to the atmosphere.

Spent carbon would be regenerated on-site using steam. The condensate from GAC unit would be sent to a recycling unit.

Treated groundwater would be discharged to a sanitary sewer. Additional treatment for ketone removal will be required for disposal of treated groundwater to a surface drain, or reuse for groundwater recharge or industrial purposes. Ketone removal has been



Douglas Aircraft Company
Torrance (C6) Facility
Carbon Adsorption Treatment System
Alternative 1
Figure 4-1

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considered as an option in this feasibility study, and therefore, is not presented with the treatment alternative.

A flow schematic for the air stripping/carbon adsorption alternative is presented in Figure 4-1.

Alternative 2: Groundwater Treatment with Air Stripper/Vapor Phase Treatment with Catalytic Oxidation and Caustic Scrubber

This alternative would include the following processes.

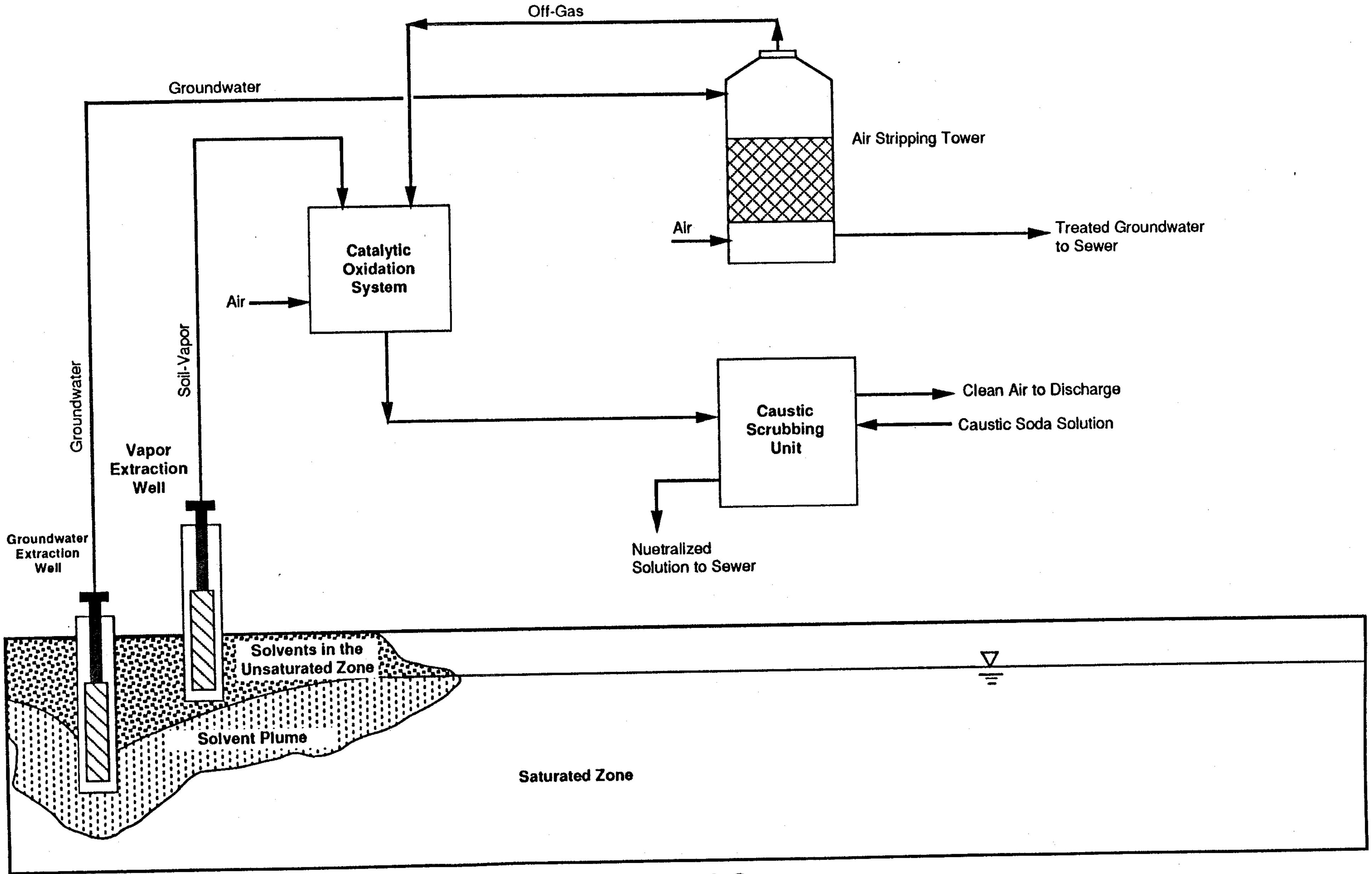
- Soil-Vapor Extraction
- Catalytic Oxidation of Vapor Phase
- Groundwater Extraction
- Groundwater Treatment with Air Stripper
- Off-gas Treatment by Catalytic Oxidation
- Caustic Scrubbing of Vapor Stream
- Disposal of Treated Groundwater to a Sewer
- Discharge of Treated Air Stream
- Ketone Removal with a Rotating Biological Contactor (for other disposal options)

Alternative 2 would reduce the level of hydrocarbons in the unsaturated zone by inducing a flow of air through the soil to vaporize the volatile hydrocarbons. Hydrocarbons would be removed from the resulting air stream using a catalytic oxidation process. A vapor extraction pilot test will be required to determine the actual radius of influence which can be achieved by each vapor well.

Groundwater extraction wells would pump hydrocarbons containing groundwater to the surface for treatment. Pumping groundwater from the aquifer gradually removes the hydrocarbons from the acquifer. An additional pump test needs to be performed prior to implementing this alternative to verify that adequate recovery rates can be achieved with each well.

Counter-flow, packed tower air stripping would be employed for groundwater treatment. Air stripping will remove 99 percent of the aromatics and hydrocarbons and transfer them to the air stream. The majority of ketones (MEK and MIBK) will remain in the liquid stream. The vapor stream would then pass through a catalytic oxidation where hydrocarbons would be converted to by-products like water and carbon dioxide and hydrochloric acid.

The combined air stream from catalytic oxidation unit would then pass through a caustic scrubber where hydrochloric acid would be neutralized with a caustic soda solution. The treated air stream would be emitted to the atmosphere.



Douglas Aircraft Company
Torrance (C6) Facility
Catalytic Oxidation Treatment System
Alternative 2
Figure 4-2

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Treated groundwater would be discharged to a sanitary sewer. Additional treatment for ketone removal will be required for disposal of treated groundwater to a surface drain, or reuse for groundwater recharge or industrial purposes. The ketone removal has been considered as an option in this feasibility study, and therefore, is not presented with the treatment alternative.

A flow schematic for the air stripping/catalytic oxidation alternative is presented in Figure 4-2.

Alternative 3: Groundwater Treatment with Air Stripper/Vapor Phase Treatment with Resin Adsorption-Desorption Process

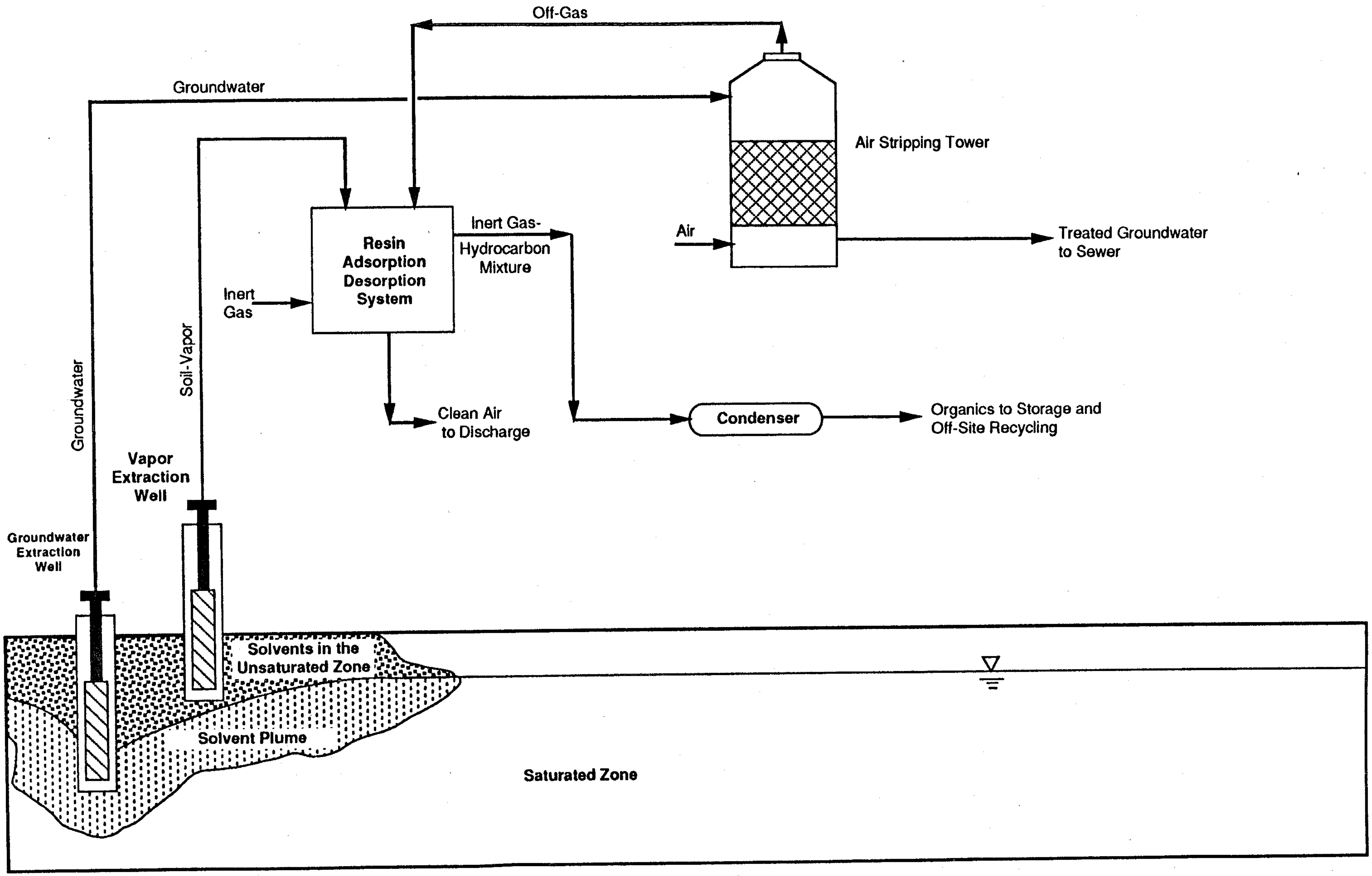
This alternative would include the following processes.

- Soil-Vapor Extraction
- Resin Adsorption of Vapor Phase
- Groundwater Extraction
- Groundwater Treatment with Air Stripper
- Off-gas Treatment by Resin Adsorption
- Desorption of Resin Bed
- Recycling of Organic Compounds
- Disposal of Treated Groundwater to a Sewer
- Discharge of Treated Air Stream
- Ketone Removal with a Rotating Biological Contactor (for other disposal options)

Alternative 3 would reduce the level of hydrocarbons in the unsaturated zone by inducing a flow of air through the soil to vaporize the volatile hydrocarbons. Hydrocarbons would be removed from the resulting air stream using a resin adsorption process. A vapor extraction pilot test will be required to determine the actual radius of influence which can be achieved by each vapor well.

Groundwater extraction wells would pump hydrocarbon-containing groundwater to the surface for treatment. Pumping groundwater from the aquifer gradually removes the hydrocarbons from the acquifer. An additional pump test needs to be performed prior to implementing this alternative to verify that adequate recovery rates can be achieved with each well.

Counter-flow, packed tower air stripping would be employed for groundwater treatment. Air stripping will remove 99 percent of the aromatics and chlorinated hydrocarbons and transfer them to the air stream. The majority of ketones (MEK and MIBK) will remain in the liquid stream. The vapor stream would then pass through a resin adsorption system where the hydrocarbons would be adsorbed on the resin bed. The treated air would be emitted to the atmosphere.



Douglas Aircraft Company
Torrance (C6) Facility
Resin Adsorption-Desorption Treatment System
Alternative 3
Figure 4-3

BOE-C6-0060997

Spent resin would be regenerated within the system using an inert gas. The organic laden inert gas stream would then be condensed to recover an organic compound-water mixture. This mixture would be sent to a recycling unit for solvent recovery.

Treated groundwater would be discharged to a sewer. Additional treatment for ketone removal will be required for disposal of treated groundwater to a surface drain, or reuse for groundwater recharge or industrial purposes. The ketone removal has been considered as an option in this feasibility study, and therefore, is not presented with the treatment alternative.

A flow schematic for the air stripping/resin adsorption-desorption alternative is presented in Figure 4-3.

BOE-C6-0060998

Chapter 5

JMM James M. Montgomery

CHAPTER 5

DETAILED ANALYSIS OF ALTERNATIVES

INTRODUCTION

The assembled alternatives identified in Chapter 4 were based upon the results of screening evaluations, site specific conditions, and cleanup objectives. Table 5 summarizes the applicable alternatives developed in Chapter 4. This chapter presents the detailed analysis of the assembled alternatives. The detailed analysis of alternatives is intended to provide decision-makers with sufficient information concerning a range of proposed remedial actions to select a single remedy that meets the following criteria:

- Technical analysis for effectiveness, implementability and reliability
- Protective of human health and the environment
- Institutional analysis for compliance with ARARs and discharge limits
- Economic analysis for most cost-effective treatment system

Additional groundwater treatment for ketone (MEK and MIBK) removal will be required if surface discharge, groundwater recharge or industrial use of treated groundwater is desired. The additional ketone treatment has been considered optional in this feasibility study. The detailed analysis of the ketone removal process along with the estimated capital and operating costs are presented at the end of this chapter.

Alternative 1: Groundwater Treatment with Air Stripper/Vapor Phase Treatment with Carbon Adsorption with On-site Regeneration

Groundwater Action

Technical Analysis. Organic compounds are present in an aquifer below solvent-laden soils at the Torrance site. A conceptual design of a groundwater extraction and treatment system was developed for remediation of hydrocarbons.

To develop the conceptual design of a groundwater extraction well network necessary to effectively remediate VOCs in groundwater at the site, a numerical analysis was performed using available data and techniques. Scenarios investigated included using different numbers and locations for extraction wells and different pumping rates. The analysis results indicate that groundwater mitigation would require extraction at a rate of 10 gallons per minute (gpm) from each of ten (10) wells, producing a total flow rate of 100 gpm from all wells.

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TABLE 5

SUMMARY OF APPLICABLE ALTERNATIVES

Alternative	Soil Action	Groundwater Action
Alternative 1	Vapor extraction and treatment with carbon adsorption.	Extraction and treatment with air stripping. Off-gas treatment with carbon adsorption system.
Alternative 2	Vapor extraction and treatment with catalytic oxidation system.	Extraction and treatment with air stripping. Off-gas treatment with catalytic oxidation system.
Alternative 3	Vapor extraction and treatment with resin adsorption-desorption system.	Extraction and treatment with air stripping. Off-gas treatment with resin adsorption-desorption system.

The groundwater would be pumped through an extraction well network consisting of all shallow wells at the site, except the two upgradient wells, WCC-2S and WCC-10S. The proposed extraction well network would consist of existing 4-inch diameter PVC extraction/monitoring wells screened from approximately 70 to 90 feet below ground surface. Groundwater would be pumped from the wells to a holding tank where flows would be metered and well operation would be automatically controlled. Treatment would be applied to the cumulative discharge from all wells on the system. The pipeline between the wells and the buildings could be constructed using 4-inch PVC pipe. The total flow rate from the proposed on-site extraction system for this alternative is approximately 100 gpm. Prior to well installation, pump tests would need to be performed on the well system to verify that proposed flow rates can be realized.

Once extracted, groundwater would be treated on-site. For this alternative, a groundwater treatment system was conceptually designed based on air stripping. An air stripping system would consist of a 40-foot high vertical packed column in which water flows downward, contacting upward flowing air. VOCs would be transferred from the water phase to the air phase in the tower. The tower would have a diameter of 3 feet and a minimum of 30 feet of 1.5-inch packing. The air-to-water ratio (A/W) for the tower would be 60 (volume to volume). The tower would be constructed of a material that would prevent light from entering the tower and thus reduce the potential for biofouling to occur. Effluent gases containing VOCs from the air stripping treatment system would be combined with the soil-vapors and sent to a vapor phase treatment system.

Based on average VOC concentrations and a flow rate of 100 gpm, it is anticipated that the treated groundwater would contain less than 1.0 mg/l TTOs, except ketones (MEK and

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MIBK). The effluent would be discharged to a sanitary sewer.

All site activities planned under this alternative are technically feasible. Extraction well systems have been commonly used in the past for removal of hydrocarbons from groundwater. Few difficulties are expected to be encountered during construction and operation of the groundwater extraction and treatment system. Air stripping is well-developed and has been used to treat VOCs in groundwater at many sites across the country. Monitoring of the extraction and treatment system would be necessary to assess its integrity and performance. Sampling of the treatment system influent and effluent would be performed on a routine basis to assess system performance. No difficulties are anticipated with long-term maintenance or replacement of site equipment.

Technologies necessary for construction and installation of groundwater extraction and treatment systems are widely available and sufficiently demonstrated for this specific application.

Institutional Analysis. Current conditions at the Torrance site exceed California and Federal MCLs for groundwater, assuming that the aquifer is used for drinking water purposes. This alternative is theoretically expected to reduce the hydrocarbon concentration in the groundwater to below MCLs for total toxic organics. Periodic groundwater monitoring would be conducted in accordance with the RWQCB's requirements to assess the effectiveness of the remediation system. The discharge limitations for treated groundwater as set forth by County Sanitation District of Los Angeles County (CSDLAC) are 1.0 mg/l total toxic organics (TTO). Ketones are presently not regulated within the TTO limits.

The proposed treatment technology will achieve the required removal efficiencies to ensure that effluent concentrations are at or below the set discharge criteria. Therefore, this alternative complies with chemical-specific ARARs for groundwater and the CSDLAC discharge limits for the treated groundwater.

Public Health and Environmental Analysis. The hydrocarbon impacted aquifer is at present not being used for any beneficial purpose, including human consumption. Thus the aquifer does not pose any immediate threat to public health and welfare.

Installation of a groundwater extraction and treatment system should not result in any adverse short- or long-term impacts on public health. However, since this alternative requires the installation of extraction wells and construction of a treatment system, precautions should be taken to ensure worker safety. Construction activities are not expected to impact the health of the general public.

Groundwater extraction wells are an effective means of pumping groundwater and controlling groundwater flow. Extracting groundwater from the site would reduce the potential for movement of hydrocarbons laterally or to any deeper aquifers. This alternative would not cause any disruption in the environment surrounding the site. Since this alternative would treat groundwater to levels protective of human health, it would reduce future potential risks associated with groundwater use. GAC has demonstrated effectiveness in removing VOCs from groundwater. Sampling of the treatment system effluent would be performed on a periodic basis to ensure system performance.

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The overall effectiveness of this alternative to limit hydrocarbon exposure at the site to human receptors and the surrounding environment is high. This alternative would eliminate potential exposure to hydrocarbons in groundwater.

Soil Action

Technical Analysis. VOCs are present in soils surrounding the location of the former cluster of tanks 15T through 18T. The proposed remedial system includes a vapor extraction well network consisting of 4-inch-diameter extraction wells. As indicated in previous investigations by WCC, the hydrocarbons are primarily distributed over a wide range of depth within the soil (15 to 75 feet). Therefore it will be necessary to provide extraction wells at different depths to effectively remove hydrocarbons from the entire depth of soil. Based on the available data, it was assumed that two extraction wells will be screened in the shallow zone (15 to 45 feet) with a radius of influence of approximately 30-feet. In addition, four extraction wells will be provided for deeper subsurface soil and the capillary fringe zone (45 to 75 feet), each having a radius of influence of approximately 35-feet. The vapors would be extracted by means of a 30-40 Hp blower providing 150-inches water vacuum pressure. The rate of extraction would be approximately 650 scfm. Prior to well installation, a vapor extraction pilot test would need to be performed at the site to verify proposed extraction rates and the radius of influence.

Once extracted, the vapors would be combined with air stripper off-gas and treated on-site by means of an activated carbon (GAC) treatment system. The conceptual design of the GAC treatment system and the resulting cost estimate are based on average VOC concentrations detected in the unsaturated zone during Phase I, II, and III studies performed by WCC and further analysis by JMM.

An on-site regenerable, vapor phase GAC system would consist of two carbon vessels, each containing 1500 pounds of GAC. Each vessel would have a diameter of 6 feet in which air flows upward. VOCs would be transferred from the vapor phase to the activated carbon. While one vessel is on-line, the other vessel undergoes a regeneration cycle. The adsorption cycle lasts for 3-hours and is followed by the regeneration cycle.

During the regeneration cycle, steam at 220F, provided from DAC facility utility, is passed through the carbon bed for a period of 1-hour. The hydrocarbons are transferred from the carbon surface to the steam phase. The condensate from GAC unit would be sent to a recycling unit for solvent recovery. The steam cycle is followed by a 15-minute dry-air cycle prior to bringing the GAC unit on-line. The treated vapors would be emitted to the atmosphere.

Soil-vapor extraction is a very effective method for solvent-laden soil clean-up and has been used in numerous applications similar to this site. The hydrocarbons present at the Torrance site are relatively volatile and should be amenable to volatilization via vapor extraction.

All site activities planned under this alternative are technically feasible. Such systems have been successfully used in the past for cleanup of hydrocarbons in soils and few difficulties are expected to be encountered during construction and operation of the soil-vapor extraction system. GAC is a well-developed process and has been used to treat

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VOCs in vapor phase at many sites across the country. Monitoring of the extraction and treatment system would be necessary to assess its integrity and performance. Sampling of the treatment system effluent would be performed on a routine basis to assess system performance. No difficulties are anticipated with long-term maintenance or replacement of site equipment.

It should be noted that while treatment of extracted vapors is a straightforward process, it may be difficult to extract all of the hydrocarbons from the soil. Case studies have shown that with time and reduced concentrations, some hydrocarbons will volatilize very slowly from the subsurface soils and it may not be practical or possible to remove hydrocarbons completely from the site. However, the target cleanup goals identified in Chapter 2 are believed to be attainable.

Institutional Analysis. Chemical-specific ARARs pertinent to this technology include LUFT field manual guidelines for soil and the state and federal air quality regulations (Clean Air Act; California Air Resources Act) for air emissions.

Due to the high volatility of compounds present in soils at the site, a SVE system is anticipated to produce high removal efficiencies. All LUFT manual ARARs are expected to be attainable with the selected technology. Because the selected technology, extraction and treatment of soil-vapors, results in the generation of air emissions, federal, state, and local regulations are potential ARARs for this technology.

USEPA has promulgated several regulations, including National Ambient Air Quality Standards (NAAQS), National Emission Standards for Hazardous Air Pollutants (NESHAP) and New Source Performance Standards (NSPS), in addition to requirements of the Clean Air Act, all of which are potentially ARARs, depending upon the source, type and amount of annual emissions.

NAAQS are primary and secondary standards promulgated by USEPA to protect the public health (allowing adequate margin of safety) and the public welfare, respectively. Standards have been set for six criteria pollutants: particulate material equal to or less than 10 microns particle size, sulfur dioxide, carbon monoxide, ozone, nitrogen dioxide, and lead. Areas that meet these standards are designated as "attainment"; those that do not are designated as "non-attainment". Due to the nature of hydrocarbons being treated, NAAQS are not potential ARARs, and thus are not applicable.

NESHAP are promulgated for emissions of particular air pollutants from specific sources. The proposed action, removal and treatment of VOC from soils and/or groundwater, is not one of the specific source categories regulated by NESHAP, and thus these regulations are not applicable.

NSPS are standards promulgated by USEPA for categories of stationary sources that emit particular pollutants that cause, or contribute significantly, to air pollution that may reasonably be anticipated to endanger public health or welfare. As with NESHAP, these standards are source-specific, and are not applicable to the proposed treatment facility.

In addition to the federal regulations, the South Coast Air Quality Managemet District (SCAQMD) has promulgated several regulations for air emissions, including Rule 1166 and Regulation XIII (New Source Review). The five basic criteria under Regulation XIII include:

ROG	40 tons per year
NOx	40 tons per year
SOx	40 tons per year
PM_{10}	15 tons per year
CO	100 tons per year

The SCAQMD also requires a health risk analysis for toxic organics in conjunction with the design, construction and operation os a soil and groundwater remediation system. Based on previous experience with similar site conditions, it is anticipated that dischrage from the selected vapor treatment technology would attain all applicable requirements of Rule 1166 and Regulation XIII.

Based on the above presented information, it is anticipated that the potential ARAR for air will be met.

Public Health and Safety. Currently, the contaminated soil is covered with a concrete pad, thus preventing any vapors from escaping into surrounding environments. Also, the potential for dermal contact with soils is minimal as no excavation is likely to take place in a near future. Thus, there is a minimal potential for any short-term impacts on public health.

Installation of a soil-vapor extraction and treatment system should not result in any adverse short- or long-term impacts on public health. However, since this alternative requires the installation of extraction wells and construction of a treatment system, precautions should be taken to ensure worker safety. Construction activities are not expected to impact the health of the general public.

A vapor extraction well system is an effective and technically viable means of removing contaminants from soil. Extracting contaminants from soils at the site would reduce the potential for movement of contaminants vertically to aquifers. This alternative would not cause any disruption in surrounding environment at the site. Since this alternative would treat soils to levels protective of human health, it would reduce future potential risks associated with surrounding soils and groundwater use. GAC has demonstrated effectiveness in removing VOCs from extracted soil-vapors. Sampling of the treatment system's effluent would be performed on a periodic basis to ensure system performance.

The overall effectiveness of this alternative to limit exposure of site contamination to human health and surrounding environment is high. This alternative would eliminate potential exposure to contaminated soils.

Economic Analysis

A summary of costs to implement this alternative is presented in Table 5-1. Annual operating costs for this alternative are detailed in Table 5-2.

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TABLE 5-1

ESTIMATED CAPITAL COSTS FOR ALTERNATIVE I

COST ITEMS		COST
Influent Storage/Equalization Tank		$15,000
Transfer Pumps		
Air Stripping Tower		$40,000
Shell and Internals		
Packing		
Blower and Ductwork		
Transfer Pumps		
Vapor Phase Treatment GAC Contactors		$400,000
GAC Contactors		
4,000-lb Carbon for start-up		
Vapor Cooling Unit		
Inline Heater		
PLC Unit		
Decanter		
Chemical Feed System		$5,000
	Subtotal	$460,000
Installation (40%)*		$184,000
Piping and Valves (20%)*		$92,000
Electrical (10%)*		$46,000
Structural (10%)*		$46,000
Process Equipment Total		**$828,000**
Sitework		$25,000
Groundwater Collection and Conveyance		$100,000
Extraction Wellhead Modifications		
Transfer Pumps		
Conveyance Piping		

* = Percentage of mechanical equipment only.

TABLE 5-1 (continued)

ESTIMATED CAPITAL COSTS FOR ALTERNATIVE I

COST ITEMS		COST
Soil-Vapor Extraction and Conveyance		$160,000
Extraction Wells		
Blower Unit and Piping		
Pilot Test		
	Subtotal	$1,134,600
Contingency (25%)		$283,650
Total Capital Costs		**$1,418,250**

Note: 1. Costs are based on late-1992 cost.
2. Assuming air compressor is available on-site.
3. Assuming sewer connection is available at the site.
4. Assuming steam generation facilities are available on-site.

TABLE 5-2

ESTIMATED ANNUAL OPERATING COSTS FOR ALTERNATIVE I

COST COMPONENT	COST ($/Year)
Labor Cost Operators	$19,000
Chemical Cost Acids, Base, Additives	$10,000
Carbon Cost (@$2.5/pound)	$35,000
Profile Fee	$1,000
Fuel Cost for Steam Generation (@$5 per million BTU)	$3,500
Recycling Cost (@$300/drum)	$36,000
Increase in Sewer Use Fee	$20,000
Electrical Power Consumption Cost (@$0.1/kw-hr)	$63,000
Fuel Cost for Air Stream Heater (@$5 per million BTU)	$3,800
Analysis Chemicals, Miscellaneous Supplies, Etc.	$10,000
Total Annual Operating Cost	**$201,300**

Notes: 1. Annual costs are for Year-1. Annual cost for subsequent years will be lower due to decreasing hydrocarbon concentration.

Alternative 2: Groundwater Treatment with Air Stripper/Vapor Phase Treatment with Catalytic Oxidation and Caustic Scrubber

Groundwater Action

Technical Analysis. The technical analysis for this alternative is similar to that of Alternative 1.

Institutional Analysis. The institutional analysis for this alternative is similar to that of Alternative 1.

Public Health and Safety. The public health and safety analysis for this alternative is similar to that of Alternative 1.

Soil Action

Technical Analysis. The conceptual design of the soil-vapor extraction system is similar to that described in Alternative 1. However, this alternative considers a catalytic oxidation process for destruction of organic compounds in the vapor stream.

The catalytic oxidation process involves thermal incineration of the organic contents in the presence of a catalyst. In this process, the air stream is first preheated by passing it through a primary heat exchanger and into the burner chamber. The preheated air is then uniformly distributed over a catalyst matrix where the contaminant vapor destruction takes place. The destruction process is an exothermic reaction whereby the hydrocarbons or chlorinated hydrocarbons are converted to by-products such as carbon dioxide, water and hydrochloric acid.

The catalytic incineration system operates at about 600F and would be designed to treat 1450 scfm (combined flow rate of soil-vapors and air stripper off-gas). The catalytic chamber would be constructed of a material that resists corrosion in the presence of hydrochloric acid. A special catalyst, that is not poisoned by chlorinated solvents, would be employed in the catalytic oxidation chamber.

Upon exiting the catalytic chamber, the vapor stream is passed through a caustic scrubber for treatment of generated hydrochloric acid. The caustic scrubber consists of a packed bed with caustic solution recirculating through it. As the vapor stream travels upwards through the bed, it comes in contact with the caustic solution. The hydrochloric acid is neutralized in this process and clean air exits from the top.

Prior to exhausting clean air to the atmosphere, it is passed through another heat exchanger to transfer heat energy back to the incoming stream, thus minimizing the system energy costs.

All site activities planned under this alternative are technically feasible. Such systems have been successfully used in the past for cleanup of solvent-laden soils and few difficulties are expected to be encountered during construction and operation of the soil-vapor extraction system. Catalytic oxidation is a well-developed process and has been used to treat VOCs in vapor streams at many sites across the country. Monitoring of the

TABLE 5-3

ESTIMATED CAPITAL COSTS FOR ALTERNATIVE II

COST ITEMS		COST
Influent Storage/Equalization Tank		$15,000
Transfer Pumps		
Air Stripping Tower		$40,000
Shell and Internals		
Packing		
Blower and Ductwork		
Transfer Pumps		
Vapor Phase Catalytic Oxidation Process		$240,000
Catalytic Incinerator with Catalyst		
Blower		
Burner and Gas Train		
Caustic Scrubber for HCl Treatment		
Heat Exchanger		
Chemical Feed System		$5,000
	Subtotal	$300,000
Installation (40%)*		$120,000
Piping and Valves (20%)*		$60,000
Electrical (10%)*		$30,000
Structural (10%)*		$30,000
Process Equipment Total		**$540,000**
Sitework		$25,000
Groundwater Collection and Conveyance		$100,000
Extraction Wellhead Modifications		
Transfer Pumps		
Conveyance Piping		

* = Percentage of mechanical equipment only.

TABLE 5-3 (continued)

ESTIMATED CAPITAL COSTS FOR ALTERNATIVE II

COST ITEMS		COST
Soil-Vapor Extraction and Conveyance		$160,000
Extraction Wells		
Blower Unit and Piping		
Pilot Test		
	Subtotal	$825,000
Contingency (25%)		$206,250
Total Capital Costs		**$1,031,250**

Note: 1. Costs are based on late-1992 cost.
2. Assuming air compressor is available on-site.
3. Assuming sewer connection is available at the site.

TABLE 5-4

ESTIMATED ANNUAL OPERATING COSTS FOR ALTERNATIVE II

COST COMPONENT	COST ($/Year)
Labor Cost Operators	$23,000
Chemical Cost pH Control, Additives	$10,000
Fuel Cost for Catalytic Chamber (@$5 per million BTU)	$24,000
Catalyst Change, 1/yr	$24,000
Caustic Solution Cost (@$0.25/pound)	$12,000
Increase in Sewer Use Fee	$20,000
Electrical Power Consumption Cost (@$0.1/kw-hr)	$84,000
Fuel Cost for Air Stream Heater (@$5 per million BTU)	$3,800
Analysis Chemicals, Miscellaneous Supplies, Etc.	$10,000
Total Annual Operating Cost	**$210,800**

Notes: 1. Annual costs are for Year-1. Annual cost for subsequent years will be lower due to decreasing hydrocarbon concentration.

extraction and treatment system would be necessary to assess its integrity and performance. Sampling of the treatment system effluent would be performed on a routine basis to assess system performance. No difficulties are anticipated with long-term maintenance or replacement of site equipment.

It should be noted that while treatment of extracted vapors is a straightforward process, it may be difficult to extract all of the hydrocarbons from the soil. Case studies have shown that with time and reduced concentrations, some hydrocarbons will volatilize very slowly from the subsurface soils and it may not be practical or possible to remove hydrocarbons completely from the site. However, the target cleanup goals identified in Chapter 2 are believed to be attainable.

Institutional Analysis. The effluent from the catalytic oxidation process is anticipated to be similar or better than from the activated carbon treatment system. In addition, when compared with an activated carbon system, the catalytic oxidation system is not expected to emit any additional hydrocarbons to the atmosphere. Therefore, the institutional analysis for this alternative is similar to that of Alternative 1.

Public Health and Safety. Installation of a catalytic oxidation system should not result in any short- or long-term impacts on public health. Moreover, the construction activities under this alternative are not expected to impact the health of the general public. Therefore, the public health and safety analysis for this alternative is similar to that of Alternative 1.

The overall effectiveness of this alternative to limit exposure of hydrocarbons at the site to human receptors and the surrounding environment is high. This alternative would eliminate potential exposure to hydrocarbons at the site.

Economic Analysis

A summary of the cost to implement this alternative is presented in Table 5-3. Annual operating costs for this alternative are detailed in Table 5-4.

Alternative 3: Groundwater Treatment with Air Stripper/Vapor Phase Treatment with Resin Adsorption-Desorption Process

Groundwater Action

Technical Analysis. The technical analysis for this alternative is similar to that of Alternative 1.

Institutional Analysis. The institutional analysis for this alternative is similar to that of Alternative 1.

Public Health and Safety. The public health and safety analysis for this alternative is similar to that of Alternative 1.

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Soil Action

Technical Analysis. The conceptual design of the soil-vapor extraction system is similar to that described in Alternative 1. However, this alternative considers the resin adsorption-desorption process for treatment of organic compounds in the vapor stream.

In the resin adsorption-desorption process, the hydrocarbons are passed through resin beds where the hydrocarbons are adsorbed on the resin surface. The system consists of three resin adsorption beds. While two beds are on-line, the third bed undergoes a desorption cycle.

The resin is a proprietary material which has a high affinity for adsorbing hydrocarbons, but is easily regenerated using an inert gas. During the desorption, the hydrocarbons are stripped from the resin beds using an inert gas and then condensed to yield a hydrocarbon-water mixture. This mixture is stored in a special containment system and sent to a recycling facility for solvent recovery. Used inert gas is emitted to the atmosphere.

The adsorption-desorption system will be designed to handle 1450 scfm, the expected total flow rate of soil-vapors and the air stripper off-gas. The construction of the adsorption chamber would be of a material that resists corrosion due to chlorinated solvents.

The treated air stream will be emitted to the atmosphere.

All site activities planned under this alternative are technically feasible. Such systems have been successfully used in the past for cleanup of solvent-laden soils and few difficulties are expected to be encountered during construction and operation of the soil-vapor extraction system. Although this system has yet not been fully proven in this type of application, it has been used extensively in the chemical process industry for recovery of solvents. Monitoring of the extraction and treatment system would be necessary to assess its integrity and performance. Sampling of the treatment system effluent would be performed on a routine basis to assess system performance. No difficulties are anticipated with long-term maintenance or replacement of site equipment.

It should be noted that while treatment of extracted vapors is a straightforward process, it may be difficult to extract all of the hydrocarbons from the soil. Case studies have shown that with time and reduced concentrations, some hydrocarbons will volatilize very slowly from the subsurface soils and it may not be practical or possible to remove hydrocarbons completely from the site. However, the target cleanup goals identified in Chapter 2 are attainable.

Institutional Analysis. The effluent from the resin adsorption-desorption process is anticipated to be similar or better than that from the activated carbon treatment system. In addition, when compared with an activated carbon system, this system is not expected to emit any additional hydrocarbons to the atmosphere. Therefore, the institutional analysis for this alternative is similar to that of Alternative 1.

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TABLE 5-5 (continued)

ESTIMATED CAPITAL COSTS FOR ALTERNATIVE III

COST ITEMS		COST
Soil-Vapor Extraction and Conveyance		$160,000
Extraction Wells		
Blower Unit and Piping		
Pilot Test		
	Subtotal	$708,000
Contingency (25%)		$177,000
Total Capital Costs		**$885,000**

Note: 1. Costs are based on late-1992 cost.
2. Assuming air compressor is available on-site.
3. Assuming sewer connection is available at the site.

TABLE 5-6

ESTIMATED ANNUAL OPERATING COSTS FOR ALTERNATIVE III

COST COMPONENT	COST ($/Year)
Labor Cost Operators	$12,000
Chemical Cost pH Control, Additives	$10,000
Yearly Service Contract*	$11,000
Total Regeneration Cost**	$41,250
Recycling Cost (@$300/drum)	$36,000
Increase in Sewer Use Fee	$20,000
Electrical Power Consumption Cost (@$0.1/kw-hr)	$46,200
Fuel Cost for Air Stream Heater (@$5 per million BTU)	$3,800
Analysis Chemicals, Miscellaneous Supplies, Etc.	$10,000
Total Annual Operating Cost	**$190,250**

* includes maintenance and labor on system
** includes electrical cost and inert gas cost for resin regeneration

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Public Health and Safety. Installation of a catalytic oxidation system should not result in any adverse short- or long-term impacts on public health. Moreover, the construction activities under this alternative are not expected to impact the health of general public. Therefore, the public health and safety analysis for this alternative is similar to that of Alternative 1.

The overall effectiveness of this alternative to limit exposure of hydrocarbons at the site to human receptors and the surrounding environment is high. This alternative would eliminate potential exposure to hydrocarbons site.

Economic Analysis. A summary of costs to implement this alternative is presented in Table 5-5. Annual operating costs for this alternative are detailed in Table 5-6.

Ketone Removal Technology

As stated previously, ketone removal will be required for use of disposal options including surface water discharge, groundwater recharge and use for industrial processes. Based on the treatment technology selection presented in Chapter 3, a rotating biological contactor (RBC) was the only technology retained for ketone removal from groundwater at the Torrance site. This section presents a detailed description of a RBC.

The extracted groundwater is pumped to a tank where the groundwater comes in contact with a rotating biological contactors. Rotating while partially submerged, the biological contactors provide a fixed-film media for aerobic biological growth to attach to. The highly-active biomass absorbs and oxidizes ketones as it rotates through the groundwater. Exposing the growth to air at the top of the rotation provides for the absorption of oxygen. The active biomass in the reactor from mixed-liquor-recycle provides further oxidation of the substrate. The overall effect is oxidation of complex ketone molecules to harmless byproducts such as carbon dioxide and water.

Since most of the carbon and nitrogen in the groundwater, the source of food for microbial growth, will be removed upstream during an air stripping process, nutrient addition will be required to promote and sustain biological growth in the fixed film.

Based on an average ketone concentration of 12 mg/l and a flow rate of 100 gpm, it is anticipated that the treated groundwater would contain less than 1.0 mg/l total ketone.

RBCs have been used in the past for biological degradation of ketoness in the municipal and industrial wastewaters, and in extracted groundwaters. Sampling of the treatment system influent and effluent would be performed on a routine basis to assess system performance. No difficulties are anticipated with long-term maintenance or replacement of site equipment.

A biodegradation pilot study could be required prior to development of a detail design criteria. The pilot study would include determination of loading rate, surface area of rotating contactors, system retention time, recycle rate and other pertinent process parameters.

An estimate of the capital and operating costs for a RBC are provided in Table 5-7.

TABLE 5-7

ESTIMATED CAPITAL AND OPERATING COSTS FOR KETONE REMOVAL ROTATING BIOLOGICAL CONTACTOR

COST ITEMS		COST
Rotating Biological Contactor (RBC)		$85,000
Reactor Shaft		
Blower for Air Driven Shaft		
Concrete Water Basin		
Sedimentation Tank		
Miscellaneous		
	Subtotal	$85,000
Installation (40%)*		$34,000
Piping and Valves (20%)*		$17,000
Electrical (10%)*		$8,500
Structural (10%)*		$8,500
Process Equipment Total		**$153,000**
Pilot Test		$45,000
Equipment and Material		
Labor		
	Subtotal	$198,000
Contingency (25%)		$49,500
Total Capital Cost		**$247,500**
Labor Cost (Operators @ $40/hr)		$7,300
Electrical Power Costs (@ $0.1/kw-hr)		$5,000
Metering Pump (@ 0.5 Hp)		
Air blower (@ 3 Hp)		
Nutrient Supply		$5,000
Analysis Chemicals, Miscellaneous Supplies, etc.		$5,000
Total Annual Operating Costs		**$22,300**

Note: * = percentage of mechanical equipment only
1. Costs are based on late-1992 cost.

Chapter 6

CHAPTER 6

RECOMMENDATIONS

INTRODUCTION

The objectives of the remedial action in this feasibility study are:

- Minimize further migration of hydrocarbons from the unsaturated zone to the groundwater.

- Minimize migration of hydrocarbons within the groundwater.

- Reduce the level of hydrocarbons in the groundwater to provide adequate protection of public health and the environment and to attain applicable, relevant and appropriate requirements (ARARs).

A wide range of candidate technologies were screened for their ability to contribute to achieving these objectives at this site. From the screened technologies, three remedial action alternatives were assembled. Further, the ketone removal process is presented as an option to allow surface discharge, reinjection, or other reuse of the treated groundwater. These alternatives are summarized briefly below:

Alternative 1: Groundwater Treatment with Air Stripper/Vapor Phase Treatment with Carbon Adsorption with On-site Regeneration

Ten extraction wells would be used to minimize further migration of hydrocarbons in groundwater. The hydrocarbon containing groundwater, extracted at a rate of 100 gallons per minute, would be pumped to an air stripper system for treatment. The air stripper off-gas would be combined with the soil-vapors for further vapor phase treatment.

A soil-vapor extraction system would be installed for removal of hydrocarbons from the unsaturated zone. The soil-vapor extraction would enhance volatilization of the VOCs and effectively volatilize these hydrocarbons from the soil. The soil-vapors would be combined with air stripper off-gas and passed through a carbon system to remove VOCs.

The spent carbon would be regenerated on-site using steam available from DAC facility utility. The organic constituents would be sent to a recycling unit.

Each of the remaining alternatives include the groundwater extraction and treatment system, and the soil-vapor extraction system as described above. The only difference would be in the vapor phase treatment system.

Alternative 2: Groundwater Treatment with Air Stripper/Vapor Phase Treatment with Catalytic Oxidation and Caustic Scrubber

The combined vapor stream from the air stripper off-gas and the soil-vapors would be sent to a catalytic oxidation system. In the catalytic incinerator, the hydrocarbons would be converted to by-products including carbon dioxide, water, and chloride ions. The exiting air stream would then pass through a caustic scrubber for acid neutralization.

Alternative 3: Groundwater Treatment with Air Stripper/Vapor Phase Treatment with Resin Adsorption-Desorption Process

The combined vapor stream from the air stripper off-gas and the soil-vapors would be sent to a resin adsorption-desorption system for VOCs removal. Once the hydrocarbons are transferred onto resin surface, the organics are desorbed using an inert gas. The inert gas-hydrocarbon mixture is then condensed to separate the organics and sent to a recycling unit.

Ketone Removal with a Rotating Biological Contactor

Ketone removal could be achieved with a fixed-film process, such as a rotating biological contactor (RBC). A RBC is an attached-growth process where the media are rotated through a basin of groundwater. The microorganisms attached to media act on ketones in the groundwater, converting ketones to simple by-products such as carbon dioxide and water. The ketone removal has been considered optional in this feasibility study.

COMPARISON OF ALTERNATIVES

In Chapter 5, the alternatives were analyzed in detail based on technical issues, institutional issues, public health and environmental issues, and cost. Results of that analysis are summarized in Table 6-1.

RECOMMENDED ALTERNATIVE

Table 6-1 provides a summary of the alternatives analysis. From the table it can be noted that all alternatives are capable of meeting the cleanup objectives. In addition, the environmental and public health concerns, and institutional issues are similar for all alternatives. Therefore, the selection of the recommended alternative has been based on the cost analysis.

The 5-year present worth analysis shows Alternative 3 (resin adsorption-desorption treatment system) to be the most cost effective system for groundwater and unsaturated zone remediation at the Torrance (C6) Facility.

As stated in Table 6-1, the resin adsorption-desorption process is an innovative technology in this field of application. However, this technology has been extensively used in the chemical process industry for solvent recovery, and is anticipated to be successful for vapor phase treatment at the site. The manufacturer has offered a process guarantee, including meeting the discharge criteria.

TABLE 6-1

SUMMARY OF ALTERNATIVES ANALYSIS

Alternative	Capital Investment ($1000)	5-yr PW[1] ($1000)	Technical Concerns	Environmental and Public Health Concerns	Institutional Issues	Consistency with Final Objective	Disposal of Hydrocarbons
On-site Regenerable Carbon Adsorption	$1,418	$2,181	Demonstrated technology.	Removes hydrocarbons from saturated and unsaturated zone. Complies with ARARs.	Subject to surface water and air discharge standards.	Meets remedial action objectives.	Requires handling and disposal of recovered solvents.
Catalytic Oxidation Treatment	$1,031	$1,830	Demonstrated technology.	Same as Alternative 1.	Same as Alternative 1.	Meets remedial action objectives.	Does not generate any organic compounds.
Resin Adsorption-Desorption Treatment	$885	$1,606	Innovative technology. Good likelihood of success. Process can be guaranteed.	Same as Alternative 1.	Same as Alternative 1.	Meets remedial action objectives.	Requires handling and disposal of recovered solvents.
Rotating Biological Contactor (for other disposal options)	$153	$332	Demonstrated technology.		Same as Alternative 1.	Meets remedial action objectives.	Generated a minor quantity of sludge which can be discharged to a sanitary sewer.

1. 5-year present worth analysis for capital and operating cost for alternative(s).

Therefore, from the analysis of groundwater and unsaturated zone conditions at the Torrance (C6) Facility presented in this feasibility study, the following remediation alternative is recommended:

1. Groundwater extraction at a rate of 10 gpm from an individual well;

2. Ten groundwater extraction wells to be operated simultaneously producing a total flow rate of 100 gpm;

3. Air stripping system for groundwater treatment;

4. Air stripper off-gas treatment by resin adsorption-desorption process;

5. Soil-vapor extraction and treatment by resin adsorption-desorption process;

6. Discharge of treated groundwater to a sanitary sewer; Options exist for discharge of treated groundwater to a surface drain or reuse for groundwater recharge or industrial use. However, additional treatment for ketone removal will have to be provided to use these discharge options.

7. Recycling of organic compounds for solvent recovery.

ADDITIONAL DATA REQUIREMENTS

As stated earlier, sufficient data is not available at present to define the full extent of the hydrocarbon plume. It is recommended that additional field analysis be conducted to provide the following:

1. Better delineation of the extent to which hydrocarbons have migrated in the soil.

2. A soil-vapor extraction pilot test to confirm design criteria such as vapor well radius of influence.

3. Better delineation of the extent of the hydrocarbon plume in the groundwater, particularly to the south and southwest.

4. Step draw-down test in several wells to verify the pumping rates that can be achieved.

The results from this recommended field analysis will be combined with results from the previous investigations by WCC and JMM to develop the detailed design for the selected alternative for the groundwater and unsaturated zone soil remediation.

Chapter 7

SECTION 7

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Appendix A

APPENDIX A

HISTORICAL DATA

TABLE 5
GROUND WATER ANALYTICAL DATA AT DOUGLAS AIRCRAFT C6 FACILITY, TORRANCE, CALIFORNIA
(Concentration in ug/l)

WELL I.D.	SAMPLE DATE	COMPOUND									
		1,1-DCE	1,1-DCA	1,1,1-TCA	TCE	MIBK	trans-1,2-DCE	Chloroform	Toluene	Benzene	cis-1,2-DCE
WCC-1S	03/27/87	2,800		300	4,600	--	--	--	--	85	--
	04/13/87*	3,700/2,500	--/--	260/120	5,500/3,600	--/--	--/--	--/--	--/--	110/--	--
	11/12/87	3,000	23	160	5,200	--	75	39	--	160	--
	07/13/89	900	<20	67	2,400	<100	<20	<20	<20	<20	<20
	08/23/89	1,500	<30	<30	2,800	<100	<30	<30	<30	<30	41
WCC-2S	11/02/87	5	--	5	14	--	--	--	6	--	--
	11/12/87	2	--	--	4	--	--	--	1	--	--
	07/13/89	<1	<1	<1	5	<5	<1	<1	<1	<1	<1
	08/23/89	<1	<1	<1	3	<5	<1	<1	<1	<1	<1
WCC-3S	11/02/87	38,000	--	110,000	10,000	54,000	--	--	80,000	--	--
	11/12/87	88,000	1,000	54,000	11,000	70,000	1,000	--	140,000	--	--
	07/13/89	18,000	<500	56,000	7,700	<3,000	660	<500	32,000	<500	<500
	08/23/89	56,000	<1,000	78,000	6,000	<5,000	<1,000	<1,000	56,000	<1,000	<1,000
WCC-4S	11/02/87	360	--	14	700	--	2	2	--	--	--
	11/12/87	1,200	--	35	690	--	--	--	--	--	--
	07/13/89	170	<3	11	270	<20	<3	<3	<3	<3	10
	08/23/89	360	<5	7	,410	<30	<5	<5	<5	<5	15
WCC-5S	11/30/87	7	--	--	1	--	--	--	1	--	--
	01/08/88	4	--	--	10	--	--	--	--	--	--
	07/13/89*	3/3	<1/<1	<1/<1	13/12	<5/<5	<1/<1	<1/<1	<1/<1	<1/<1	6/6
	08/23/89	<1	<1	<1	12	<5	<1	<1	<1	<1	4
WCC-6S	10/6/89 ?	210	4	130	140	<5	7	<1	<1	<1	12
WCC-7S	07/13/89	850	<10	110	1,300	<50	11	<10	<10	<10	26
	08/23/89	1,100	<30	66	1,400	<100	<30	<30	<30	<30	31
WCC-8S	07/13/89	430	<5	160	240	<30	9	<5	<5	<5	7
	08/23/89	820	<5	130	430	<30	<5	<5	<5	<5	7
WCC-9S	10/6/89 ?	<1	<1	<1	15	<5	<1	<1	<1	<1	7
WCC-10S	07/13/89*	2/1	<1/<1	<1/<1	86/87	<5/<5	<1/<1	3/3	<1/<1	<1/<1	<1/<1
	08/23/89	4	<1	<1	81	<5	<1	4	<1	<1	<1
WCC-1D	07/25/89	<1	<1	<1	2	<5	<1	<1	1	<1	1
	08/23/89	<1	<1	1	2	<5	<1	<1	<1	<1	<1
WCC-3D	07/25/89	<1	<1	49	4	<5	<1	<1	3	<1	11
	08/23/89	<10	<10	32	<10	<50	<10	<10	<10	<10	<10

* Duplicate sample also analyzed
-- Not Detected (Detection limit not specified)

TABLE 4

RESULTS OF SOIL ANALYSES

Boring Number	Depth of Sample (feet)	Halogenated and Aromatic Volatile Organics (EPA Method 8010/8020, concentrations in ppm)	
B-6	10	0.053 0.011 0.016 0.064 0.001 0.009	methylene chloride DCA TCE toluene ethylbenzene total xylenes
B-6	20	12 45 1,900 51 390	TCA TCE toluene ethylbenzene total xylene
B-6	30	48 21	toluene total xylenes
B-6	30	19 6	toluene total xylenes
B-6	40	59 23 320 2.9 21	TCA TCE toluene ethylbenzene total xylenes
B-6	50	0.06 0.09 0.53 0.035 0.31 0.03	1,1-dicholoroethylene DCA TCA TCE toluene total xylenes
B-6	60	7.7 9.9 2.9	TCA toluene total xylenes
B-7	30	0.15 0.09 1.7 0.09	TCA TCE toluene total xylenes
B-7	35	1	total xylenes
B-7	40	10 40 1	TCA toluene total xylenes

(2L-ABC/C8GW3-T3)

TABLE 4 (continued)

Boring Number	Depth of Sample (feet)	Halogenated and Aromatic Volatile Organics (EPA Method 8010/8020, concentrations in ppm)	
B-7	40	12/10 25/40 < 1	TCA toluene xylenes
B-7	50	57 880 4 41 1.7	1,1-dichloroethylene TCA 1,1,2-trichloroethane toluene total xylenes
B-7	60	20,000 600 59,000 140 450	methylene chloride 1,1-dichloroethylene TCA tetrachloroethylene toluene
B-8	45	0.27	toluene
B-8	50	0.04	toluene
B-8	60	0.04 0.44 1.0	DCA TCA toluene
B-8	65	0.05 25	TCA toluene
B-9	40	0.03 0.02 0.08 0.1	DCA TCA TCE toluene
B-9	50	0.02 0.11	TCE toluene
B-9	55	0.03 0.06	TCA toluene
WCC-6S	75	9.4 8.4 1.0 0.30	MEK MIBK Toluene Butyl Cellosolve

(2L-ABC/C8GW3-T3)

TABLE 4 (continued)

Boring Number	Depth (feet)	Halogenated and Aromatic Volatile Organics (EPA Method 8010/8020, concentrations in ppm)	
WCC-6S	80	9.2	MEK
		.24	DCE
		2.50	MIBK
		2.20	toluene
		.08	TCE
		0:70	butyl cellosolve
WCC-6S	85	.550	MEK
		.330	MIBK
		.150	toluene
		.007	TCE

Borings 8 and 9 sampled on 6/14/89, Borings 6 and 7 sampled on 6/13/89.

MEK, 2-Butanone
MIBK, 4-methyl-2-pentanone
TCA, 1,1,1-trichloroethane
TCE, trichloroethylene
DCE, 1,1-dichloroethylene

TABLE 4

ANALYTICAL RESULTS FROM SOIL BORINGS 15TB AND 17TB
(ug/g) ppm

Sample No.	Sample Depth	1,1-DCE	TCE	2-Butanone (MEK)	1,1,1-TCA	Toluene	Ethylbenzene	Total Xylenes	4 Methyl-2-Pentanone (MIBK)
15TB-3-3	10	<1	ND	ND	<1	<1	<1	<1	ND
15TB-4-3	15	ND	10	160	27	870	41	460	ND
15TB-5-3	20	ND	94	1,800	38	6,300	180	1,300	ND
17TB-2-3	5	ND	ND	ND	ND	ND	ND	ND	ND
17TB-3-3	10	ND	ND	ND	<1	<1	ND	ND	ND
17TB-5-3	20	ND	ND	ND	<1	<1	ND	ND	ND
17TB-7-3	30	ND	ND	810	ND	ND	ND	ND	840
Detection Limit									

Note:

ND - Not Detected

Borings 15TB and 17TB were installed on 24 August 1987. Boring logs and analytical data sheets are presented in [redacted] "Phase III Drilling Program at the [redacted]" dated 15 December 1987.

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TABLE 3- SUMMARY OF VOLATILE ORGANIC COMPOUNDS AT THE C6 FACILITY.

Tank/Sump Number	Boring I.D.	Analyzed Soil Depth (ft)	(MEK) 2-Butanone mg/kg (ppm)	1,1,1-TCA mg/kg (ppm)	TCE mg/kg (ppm)	Toluene mg/kg (ppm)	Ethylbenzene mg/kg (ppm)	Total Xylenes mg/kg (ppm)	(MIBK) 4-Methyl-2-Pentanone mg/kg (ppm)	1,4-Dioxane mg/kg (ppm)
10 T	10TW	10	ND	ND	ND	(15)	ND	ND	ND	ND
		15	ND	ND	ND	ND	ND	ND	ND	ND
		20	ND	ND	ND	(13)	ND	ND	ND	ND
15 T	15TB	10	(570)	ND	ND	(56)	(11)	(110)	ND	ND
		15	160	27	10	870	41	460	ND	ND
		20	1800	38	94	6300	180	1300	ND	ND
17 T	17TB	5	ND	ND	ND	ND	ND	ND	ND	ND
		10	ND	(36)	ND	(8)	ND	ND	ND	ND
		20	ND	(13)	ND	(7)	ND	ND	ND	(14)
		30	810	ND	ND	ND	ND	ND	840	ND
Detection Limit- (ppm)			50	5	5	5	5	5	30	D.L.-5
- (ppb)			(50)	(5)	(5)	(5)	(5)	(5)	(30)	(5)

NOTE: D.L.- Detection Limit
ND - Not Detected
( ) - Concentration in ug/kg (ppb)

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TABLE 3

GROUND WATER ELEVATION DATA COLLECTED 18 OCTOBER 1989
DOUGLAS AIRCRAFT C6 FACILITY, TORRANCE, CALIFORNIA

Well No.	Elevation[1] Top of Well[2] (ft)	Depth to Ground Water From top of Well (ft)	Elevation of Ground Water (ft)
WCC-1S	50.70	70.18	-19.48
WCC-2S	50.59	69.65	-19.06
WCC-3S	51.19	70.61	-19.42
WCC-4S	49.69	69.28	-19.59
WCC-5S	48.22	67.92	-19.70
WCC-6S	50.95	70.65	-19.70
WCC-7S	48.29	68.36	-20.07
WCC-8S	50.56	69.91	-19.35
WCC-9S	47.01	67.08	-20.07
WCC-10S	51.12	69.54	-18.42
WCC-1D	50.45	69.96	-19.51
WCC-3D	51.18	70.56	-19.38

1 Reference: City of Los Angeles Benchmark CY-3028, datum is Mean Sea Level (MSL).

2 Top of well is top of well casing on north side marked with permanent ink.

TABLE 1
SLUG TEST DATA REDUCTION
DOUGLAS AIRCRAFT C6 FACILITY, TORRANCE CALIFORNIA

Where:

K = Hydraulic Conductivity
Rc = Radius of well casing in feet
Re = Effective Radius of influence (ft)
Yo = Initial drawdown at time t =0 (sec)
H = Distance from base of well to SWL (ft)
A = Constant Based on L/Rw
Yt = Drawdown at time t (sec)
Dw = Depth of well (ft)
Rw = Radius of Boring in feet
L = Length of screen of saturated thickness if entire screen is not saturated in feet
t = Selected time/drawdown semi-log plot (sec)
D = Thickness of aquifer in feet (Bottom of aquifer approx. 150 feet)
B = Constant based on L/Rw

Depth to water(ft) - Measured 19 July, 30 August, and 4 October 1989.

Parameter	WCC-4S		WCC-5S		WCC-7S		WCC-8S	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT
Rc	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Rw	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
Dw	90	90	90	90	90	90	90	90
DTW	69.35	69.35	69.69	69.69	68.41	68.41	70.01	70.01
L = (Dw-DTW)*	20.65	20.65	20.31	20.31	21.59	21.59	19.99	19.99
D = (150-DTW)	80.65	80.65	80.31	80.31	81.59	81.59	79.99	79.99
H = (Dw-DTW)	20.65	20.65	20.31	20.31	21.59	21.59	19.99	19.99
A	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
B	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
L/Rw	49.17	49.17	48.36	48.36	51.40	51.40	47.60	47.60
Yo	0.87	1.5	0.65	2.05	0.84	1.5	0.94	1.5
Yt	0.28	0.33	0.16	0.61	0.38	0.7	0.62	1
t	20	20	11	10	20	20	20	20
Ln Re/Rw =	2.52584	2.52584	2.50616	2.50616	2.57881	2.57881	2.48737	2.48737
K (ft/sec) =	1.00E-04	1.34E-04	2.27E-04	2.16E-04	6.85E-05	6.58E-05	3.74E-05	3.65E-05
AVG K (ft/sec)	1.17E-04		2.22E-04		6.71E-05		3.69E-05	
AVG K (CM/SEC)	3.57E-03		6.76E-03		2.05E-03		1.13E-03	
AVG K (Gal/day/ft2)	7.56E+01		1.43E+02		4.34E+01		2.39E+01	

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TABLE 1 (Continued)

Parameter	WCC-9S		WCC-10S		WCC-1D		WCC-3D	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT
Rc	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Rw	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
Dw	90	90	90	90	140	140	140	140
DTW	67.17	67.17	69.51	69.51	70.09	70.09	70.62	70.62
L = (Dw-DTW)*	22.83	22.83	20.49	20.49	20	20	20	20
D = (150-DTW)	82.83	82.83	80.49	80.49	79.91	79.91	79.38	79.38
H = (Dw-DTW)	22.83	22.83	20.49	20.49	69.91	69.91	69.38	69.38
A	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
B	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
L/Rw	54.36	54.36	48.79	48.79	47.62	47.62	47.62	47.62
Yo	0.91	1.9	0.96	1.5	2.25	2.4	1.68	1.7
Yt	0.16	0.21	0.56	0.83	0.39	0.52	1.23	1.36
t	71	77	20	20	117	117	60	60
Ln Re/Rw =	2.64567	2.64567	2.51661	2.51661	3.19028	3.19028	3.18702	3.18702
K (ft/sec) =	4.10E-05	4.79E-05	4.78E-05	5.25E-05	3.45E-05	3.01E-05	1.20E-05	8.56E-06
AVG K (ft/sec)	4.44E-05		5.02E-05		3.23E-05		1.03E-05	
AVG K (CM/SEC)	1.36E-03		1.53E-03		9.86E-04		3.13E-04	
AVG K (Gal/day/ft2)	2.87E+01		3.24E+01		2.09E+01		6.63E+00	

BOE-C6-0061036

TABLE 2

SUMMARY OF AQUIFER HYDRAULICS TESTING

Well No.	Hydraulic Conductivity (gpd/ft^2) Slug Test[a]	Pump Test	Pump Test[b] Analysis Method	Coefficient of Storativity (S) (from pump test)
1S	--	460	Cooper Jacob	0.014
2S	NT	NM	--	--
3S	NT	ND	--	--
4S	76	470	residual drawdown	--
5S	140	NM	--	--
6S	NT	970	Cooper Jacob	0.004
7S	43	970	Cooper Jacob	0.013
8S	24	560	Cooper Jacob	0.009
9S	29	NR	--	--
10S	32	NM	--	--
1D	NT	NR	--	--
3D	6.6	NM	--	--
1S, 6S, 7S, 8S	--	860	Distance drawdown (500 minutes)	0.007

a Slug test values included for reference, generally not directly comparable to pump test values.

b WCC-4S was pumping well.

NT Not tested.

NR Not responsive.

NM Not monitored.

Appendix B

APPENDIX B

JMM ANALYTICAL DATA

MONTGOMERY LABORATORIES
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555 East Walnut Street, Pasadena, California 91101
(818) 796-9141 / (213) 681-4255 Telex 67-5420

Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Douglas Aircraft Co.		Job#:	1220.0090
**		PO#:	
**		Workorder#:	W38830
**, ** **		Report#:	R85078
Attn:	Majid Rasouli	Phone #:	6948

ate Sampled: 11/18/91 Date Received: 11/18/91
ate Analyzed: 11/26/91

ab Number: LB0351
Sample I.D.: WCC-1S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS:		
crolein	ND	2500
Acrylonitrile	ND	1000
Benzene	ND	50
romoform	ND	250
arbon Tetrachloride	ND	250
Chlorobenzene	ND	250
ibromochloromethane	ND	250
loroethane	ND	500
2-Chloroethylvinylether	ND	500
hloroform	ND	250
ichlorobromomethane	ND	250
1,1-Dichloroethane	ND	250
1.2-Dichloroethane	ND	250
.1-Dichloroethene	1300	250
,2-Dichloropropane	ND	250
Ethylbenzene	ND	250
ethyl Bromide	ND	500
ethyl Chloride	ND	500
Methylene Chloride	~~ND~~ 9.2	250
1,2,2-Tetrachloroethane	ND	250
etrachloroethene	ND	250

Not Detected
: Not Analyzed

Approved by RE Olson

APPROVED
DEC 10 1991

~~Dates~~ NOTE: Methylene chloride in Method Blank = 23 ug/L

BOE-C6-0061040

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number:	LB0351
Sample I.D.:	WCC-1S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS (continued):		
Toluene	ND	250
1,1,1-Trichloroethane	ND	250
1,1,2-Trichloroethane	ND	250
Trichloroethene	3700	250
Vinyl Chloride	ND	500
trans-1,3-Dichloropropene	ND	250
cis-1,3-Dichloropropene	ND	250
trans-1,2-Dichloroethene	ND	250
cis-1,2-Dichloroethene	ND	250
Trichlorofluoromethane	ND	250
Total Xylenes	ND	250
1,2-Dichlorobenzene	ND	250
1,3-Dichlorobenzene	ND	250
1,4-Dichlorobenzene	ND	250
HAZARDOUS SUBSTANCES COMPOUNDS:		
Acetone	ND	500
2-Butanone	ND	500
Carbon disulfide	ND	250
2-Hexanone	ND	500
4-Methyl-2-Pentanone	ND	500
Styrene	ND	250
Vinyl Acetate	ND	500

ND Not Detected
NA Not Analyzed

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number: LB0351
Sample I.D.: WCC-1S

Compound	Recovery (%)	QC Limits (%)
SURROGATE:		
4-Bromofluorobenzene	108	92-113
1,2-Dichloroethane-d4	112	92-133
Toluene-d8	105	89-114

Note: Reuslts for this sample were submitted to Montgomery Laboratories by Core Laboratories.

ND: Not Detected
NA: Not Analyzed

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Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Douglas Aircraft Co.		Job#:	1220.0090
**		PO#:	
**		Workorder#:	W38864
**, ** **		Report#:	R85294
Attn:	Majid Rasouli	Phone #:	6948

Date Sampled:	11/19/91	Date Received:	11/19/91
Date Analyzed:	11/27/91		

Lab Number:	LB0620
Sample I.D.:	WCC-2S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS:		
Acrolein	ND	50
Acrylonitrile	ND	20
Benzene	ND	1.0
Bromoform	ND	5.0
Carbon Tetrachloride	ND	5.0
Chlorobenzene	ND	5.0
Dibromochloromethane	ND	5.0
Chloroethane	ND	10
2-Chloroethylvinylether	ND	10
Chloroform	ND	5.0
Dichlorobromomethane	ND	5.0
1,1-Dichloroethane	ND	5.0
1,2-Dichloroethane	ND	5.0
1,1-Dichloroethene	30	5.0
1,2-Dichloropropane	ND	5.0
Ethylbenzene	ND	5.0
Methyl Bromide	ND	10
Methyl Chloride	ND	10
Methylene Chloride	15	5.0
1,1,2,2-Tetrachloroethane	ND	5.0
Tetrachloroethene	ND	5.0

ND: Not Detected
NA: Not Analyzed

Approved by ______________

APPROVED
DEC 10 1991

Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Lab Number:	LB0620
ample I.D.:	WCC-2S

ompound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
OLATILE PRIORITY POLLUTANTS (continued):		
Toluene	75	5.0
,1,1-Trichloroethane	8.0	5.0
,1,2-Trichloroethane	ND	5.0
richloroethene	110	5.0
Vinyl Chloride	ND	10
rans-1,3-Dichloropropene	ND	5.0
is-1,3-Dichloropropene	ND	5.0
trans-1,2-Dichloroethene	ND	5.0
is-1,2-Dichloroethene	ND	5.0
richlorofluoromethane	ND	5.0
Total Xylenes	ND	5.0
1,2-Dichlorobenzene	ND	5.0
3-Dichlorobenzene	ND	5.0
4-Dichlorobenzene	ND	5.0
AZARDOUS SUBSTANCES COMPOUNDS:		
Acetone	ND	10
-Butanone	ND	10
arbon disulfide	ND	5.0
2-Hexanone	ND	10
4-Methyl-2-Pentanone	ND	10
tyrene	ND	5.0
inyl Acetate	ND	10

ND: Not Detected
: Not Analyzed

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number:	LB0620
Sample I.D.:	WCC-2S

Compound	Recovery (%)	QC Limits (%)
SURROGATE:		
4-Bromofluorobenzene	102	92-113
1,2-Dichloroethane-d4	99	92-133
Toluene-d8	101	89-114

Note: Reuslts for this sample were submitted to Montgomery Laboratories by Core Laboratories.

ND: Not Detected
Not Analyzed

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Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Douglas Aircraft Co.		Job#:	1220.0090
**		PO#:	
**		Workorder#:	W38776
**, ** **		Report#:	R84578
Attn:	Majid Rasouli	Phone #:	6948

Date Sampled:	11/14/91	Date Received:	11/14/91
Date Analyzed:	11/27/91		

Lab Number:	LB0014
Sample I.D.:	WCC-3S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS:		
Acrolein	ND	12500
Acrylonitrile	ND	5000
Benzene	ND	250
Bromoform	ND	1250
Carbon Tetrachloride	ND	1250
Chlorobenzene	ND	1250
Dibromochloromethane	ND	1250
Chloroethane	ND	2500
2-Chloroethylvinylether	ND	2500
Chloroform	~~ND~~ 250 (EST)	1250
Dichlorobromomethane	ND	1250
1,1-Dichloroethane	~~ND~~ 400 (EST)	1250
1,2-Dichloroethane	ND	1250
1,1-Dichloroethene	12000	1250
1,2-Dichloropropane	ND	1250
Ethylbenzene	ND	1250
Methyl Bromide	ND	2500
Methyl Chloride	ND	2500
Methylene Chloride	~~ND~~ 7.1 (EST)	1250
1,1,2,2-Tetrachloroethane	ND	1250
Tetrachloroethene	ND	1250

ND Not Detected
NA Not Analyzed

Approved by REVlso

APPROVED
DEC 10 1991

Method Blank has 23 ug/L Methylene Chloride

BOE-C6-0061046

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number: LB0014
Sample I.D.: WCC-3S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS (continued):		
Toluene	27000	1250
1,1,1-Trichloroethane	6900	1250
1,1,2-Trichloroethane	ND	1250
Trichloroethene	7900	1250
Vinyl Chloride	ND	2500
trans-1,3-Dichloropropene	ND	1250
cis-1,3-Dichloropropene	ND	1250
trans-1,2-Dichloroethene	ND > total 1,2-DCE > 550 (EST)	1250
cis-1,2-Dichloroethene	ND	1250
Trichlorofluoromethane	ND	1250
Total Xylenes	ND	1250
1,2-Dichlorobenzene	ND	1250
1,3-Dichlorobenzene	ND	1250
1,4-Dichlorobenzene	ND	1250
HAZARDOUS SUBSTANCES COMPOUNDS:		
Acetone	ND	2500
2-Butanone	12000	2500
Carbon disulfide	ND	1250
2-Hexanone	ND	2500
4-Methyl-2-Pentanone	70000	2500
Styrene	ND	1250
Vinyl Acetate	ND	12500

ND: Not Detected
NA: Not Analyzed

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number:	LB0014
S mple I.D.:	WCC-3S

C mpound	Recovery (%)	QC Limits (%)
S RROGATE:		
4-Bromofluorobenzene	76	92-113
1 2-Dichloroethane-d4	103	92-133
T luene-d8	81	89-114

Note: Results for this sample were submitted to Montgomery Laboratories by Core Laboratories.

N Not Detected
N Not Analyzed

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Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Douglas Aircraft Co.
**
**
**, ** **
Attn: Majid Rasouli

Job#: 1220.0090
PO#:
Workorder#: W38830
Report#: R85077
Phone #: 6948

Date Sampled: 11/18/91
Date Analyzed: 11/26/91
Date Received: 11/18/91

Lab Number: LB0350
Sample I.D.: WCC-4S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS:		
Acrolein	ND	1000
Acrylonitrile	ND	400
Benzene	ND	20
Bromoform	ND	100
Carbon Tetrachloride	ND	100
Chlorobenzene	ND	100
Dibromochloromethane	ND	100
Chloroethane	ND	200
2-Chloroethylvinylether	ND	200
Chloroform	ND	100
Dichlorobromomethane	ND	100
1,1-Dichloroethane	ND	100
1,2-Dichloroethane	ND	100
1,1-Dichloroethene	1000	100
1,2-Dichloropropane	ND	100
Ethylbenzene	ND	100
Methyl Bromide	ND	200
Methyl Chloride	ND	200
Methylene Chloride	~~ND~~ 10.7	100
1,1,2,2-Tetrachloroethane	ND	100
Tetrachloroethene	ND	100

ND Not Detected
NA Not Analyzed

Approved by RE Olson

APPROVED
DEC 10 1991

Methylene Chloride in Method Blank = 23 ug/L

BOE-C6-0061049

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number:	LB0350
Sample I.D.:	WCC-4S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS (continued):		
Toluene	ND	100
1,1,1-Trichloroethane	~~ND~~ 20 (EST)	100
1,1,2-Trichloroethane	ND	100
Trichloroethene	2200	100
Vinyl Chloride	ND	200
trans-1,3-Dichloropropene	ND	100
cis-1,3-Dichloropropene	ND	100
trans-1,2-Dichloroethene	ND	100
cis-1,2-Dichloroethene	ND	100
Trichlorofluoromethane	ND	100
Total Xylenes	ND	100
[illegible]-Dichlorobenzene	ND	100
[illegible]-Dichlorobenzene	ND	100
1,4-Dichlorobenzene	ND	100
HAZARDOUS SUBSTANCES COMPOUNDS:		
Acetone	ND	200
2-Butanone	ND	200
Carbon disulfide	ND	100
2-Hexanone	ND	200
4-Methyl-2-Pentanone	ND	200
Styrene	ND	100
Vinyl Acetate	ND	200

ND: Not Detected
NA: Not Analyzed

Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Lab Number:	LB0350
S mple I.D.:	WCC-4S

(mpound	Recovery (%)	QC Limits (%)
S RROGATE:		
4-Bromofluorobenzene	107	92-113
: 2-Dichloroethane-d4	113	92-133
T luene-d8	104	89-114

Note: Reuslts for this sample were submitted to Montgomery Laboratories by Core Laboratories.

N Not Detected
N Not Analyzed

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(818) 796-9141 / (213) 681-4255 Telex 67-5420

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Douglas Aircraft Co.		Job#:	1220.0090
**		PO#:	
**		Workorder#:	W38864
**, ** **		Report#:	R85292
Attn:	Majid Rasouli	Phone #:	6948

ˉate Sampled:	11/19/91	Date Received:	11/19/91
ate Analyzed:	11/27/91		

ab Number:	LB0618
ample I.D.:	WCC-5S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
LATILE PRIORITY POLLUTANTS:		
crolein	ND	50
crylonitrile	ND	20
Benzene	ND	1.0
romoform	ND	5.0
arbon Tetrachloride	ND	5.0
Chlorobenzene	ND	5.0
Dibromochloromethane	ND	5.0
hloroethane	ND	10
-Chloroethylvinylether	ND	10
Chloroform	ND	5.0
ichlorobromomethane	ND	5.0
,1-Dichloroethane	ND	5.0
1,2-Dichloroethane	ND	5.0
,1-Dichloroethene	20	5.0
,2-Dichloropropane	ND	5.0
Ethylbenzene	ND	5.0
Methyl Bromide	ND	10
ethyl Chloride	ND	10
ethylene Chloride	15	5.0
1,1,2,2-Tetrachloroethane	ND	5.0
etrachloroethene	ND	5.0

ND: Not Detected
Not Analyzed

Approved by RE Wise

APPROVED
DEC 10 1991

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number:	LB0618
Sample I.D.:	WCC-5S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS (continued):		
Toluene	7.0	5.0
1,1,1-Trichloroethane	ND	5.0
1,1,2-Trichloroethane	ND	5.0
Trichloroethene	8.0	5.0
Vinyl Chloride	ND	10
trans-1,3-Dichloropropene	ND	5.0
cis-1,3-Dichloropropene	ND	5.0
trans-1,2-Dichloroethene	ND	5.0
cis-1,2-Dichloroethene	ND	5.0
Trichlorofluoromethane	ND	5.0
Total Xylenes	ND	5.0
1,2-Dichlorobenzene	ND	5.0
[illegible]-Dichlorobenzene	ND	5.0
[illegible]-Dichlorobenzene	ND	5.0
HAZARDOUS SUBSTANCES COMPOUNDS:		
Acetone	ND	10
2-Butanone	ND	10
Carbon disulfide	ND	5.0
2-Hexanone	ND	10
4-Methyl-2-Pentanone	ND	10
Styrene	ND	5.0
Vinyl Acetate	ND	10

ND Not Detected
NA Not Analyzed

Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Lab Number: LB0618
Sample I.D.: WCC-5S

Compound	Recovery (%)	QC Limits (%)
SURROGATE:		
4-Bromofluorobenzene	100	92-113
1,2-Dichloroethane-d4	98	92-133
Toluene-d8	102	89-114

Note: Results for this sample were submitted to Montgomery Laboratories by Core Laboratories.

ND: Not Detected
Not Analyzed

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Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Douglas Aircraft Co.		Job#:	1220.0090
**		PO#:	
**		Workorder#:	W38864
**, ** **		Report#:	R85293
Attn:	Majid Rasouli	Phone #:	6948

Date Sampled:	11/19/91	Date Received:	11/19/91
Date Analyzed:	11/27/91		

Lab Number: LB0619
Sample I.D.: WCC-6S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS:		
Acrolein	ND	10000
Acrylonitrile	ND	4000
Benzene	ND	200
Bromoform	ND	1000
Carbon Tetrachloride	ND	1000
Chlorobenzene	ND	1000
Dibromochloromethane	ND	1000
Chloroethane	ND	2000
2-Chloroethylvinylether	ND	2000
Chloroform	ND	1000
Dichlorobromomethane	ND	1000
1,1-Dichloroethane	ND	1000
1,2-Dichloroethane	ND	1000
1,1-Dichloroethene	5800	1000
1,2-Dichloropropane	ND	1000
Ethylbenzene	ND	1000
Methyl Bromide	ND	2000
Methyl Chloride	ND	2000
Methylene Chloride	~~ND~~ 8.6	1000
1,1,2,2-Tetrachloroethane	ND	1000
Tetrachloroethene	ND	1000

ND: Not Detected
NA: Not Analyzed

Approved by RE Olson

APPROVED
DEC 10 1991

Methylene Chloride in Method Blank = 23 µg/L

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number: LB0619
Sample I.D.: WCC-6S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS (continued):		
Toluene	35000	1000
1,1,1-Trichloroethane	5000	1000
1,1,2-Trichloroethane	ND	1000
Trichloroethene	3000	1000
Vinyl Chloride	ND	2000
trans-1,3-Dichloropropene	ND	1000
cis-1,3-Dichloropropene	ND	1000
trans-1,2-Dichloroethene	ND	1000
cis-1,2-Dichloroethene	ND	1000
Trichlorofluoromethane	ND	1000
Total Xylenes	ND	1000
1,2-Dichlorobenzene	ND	1000
1,3-Dichlorobenzene	ND	1000
1,4-Dichlorobenzene	ND	1000
HAZARDOUS SUBSTANCES COMPOUNDS:		
Acetone	ND	2000
2-Butanone	21000	2000
Carbon disulfide	ND	1000
2-Hexanone	ND	2000
4-Methyl-2-Pentanone	17000	2000
Styrene	ND	1000
Vinyl Acetate	ND	2000

ND: Not Detected
NA: Not Analyzed

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number:	LB0619
S mple I.D.:	WCC-6S

C mpound	Recovery (%)	QC Limits (%)
S RROGATE:		
4-Bromofluorobenzene	97	92-113
1 2-Dichloroethane-d4	98	92-133
T luene-d8	103	89-114

Note: Results for this sample were submitted to Montgomery Laboratories by Core Laboratories.

ND: Not Detected
NA: Not Analyzed

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(818) 796-9141 / (213) 681-4255 Telex 67-5420

Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Douglas Aircraft Co.		Job#:	1220.0090
**		PO#:	
**		Workorder#:	W38830
**, ** **		Report#:	R85070
Attn:	Majid Rasouli	Phone #:	6948

ate Sampled:	11/18/91	Date Received:	11/18/91
ate Analyzed:	11/26/91		

ab Number:	LB0348
ample I.D.:	WCC-7S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
OLATILE PRIORITY POLLUTANTS:		
crolein	ND	500
crylonitrile	ND	200
Benzene	ND	10
romoform	ND	50
arbon Tetrachloride	ND	50
Chlorobenzene	ND	50
ibromochloromethane	ND	50
hloroethane	ND	100
-Chloroethylvinylether	ND	100
Chloroform	ND	50
ichlorobromomethane	ND	50
,1-Dichloroethane	ND	50
1,2-Dichloroethane	ND	50
,1-Dichloroethene	390	50
,2-Dichloropropane	ND	50
thylbenzene	ND	50
Methyl Bromide	ND	100
ethyl Chloride	ND	100
ethylene Chloride	ND	50
1,1,2,2-Tetrachloroethane	ND	50
etrachloroethene	ND	50

ND: Not Detected
NA: Not Analyzed

Approved by RE Wilson

APPROVED
DEC 10 1991

Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Lab Number: LB0348
Sample I.D.: WCC-7S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS (continued):		
Toluene	ND	50
1,1,1-Trichloroethane	ND	50
1,1,2-Trichloroethane	ND	50
Trichloroethene	1200	50
Vinyl Chloride	ND	100
trans-1,3-Dichloropropene	ND	50
cis-1,3-Dichloropropene	ND	50
trans-1,2-Dichloroethene	ND	50
cis-1,2-Dichloroethene	ND	50
Trichlorofluoromethane	ND	50
Total Xylenes	ND	50
1,2-Dichlorobenzene	ND	50
1,3-Dichlorobenzene	ND	50
1,4-Dichlorobenzene	ND	50
HAZARDOUS SUBSTANCES COMPOUNDS:		
Acetone	ND	100
2-Butanone	ND	100
Carbon disulfide	ND	50
2-Hexanone	ND	100
4-Methyl-2-Pentanone	ND	100
Styrene	ND	50
Vinyl Acetate	ND	100

ND: Not Detected
NA: Not Analyzed

Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Lab Number: LB0348
ample I.D.: WCC-7S

ompound	Recovery (%)	QC Limits (%)
JRROGATE:		
4-Bromofluorobenzene	104	92-113
,2-Dichloroethane-d4	109	92-133
oluene-d8	103	89-114

Note: Reuslts for this sample were submitted to Montgomery Laboratories by Core Laboratories.

ND: Not Detected
A: Not Analyzed

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Revised Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Douglas Aircraft Co.		Job#:	1220.0090
**		PO#:	
**		Workorder#:	W38807
**, ** **		Report#:	R84821
Attn:	Majid Rasouli	Phone #:	6948

Date Sampled:	11/15/91	Date Received:	11/15/91
Date Analyzed:	11/27/91		

Lab Number:	LB0177
Sample I.D.:	WCC-8S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS:		
Acrolein	ND	1250
Acrylonitrile	ND	500
Benzene	ND	25
Bromoform	ND	125
Carbon Tetrachloride	ND	125
Chlorobenzene	ND	125
Dibromochloromethane	ND	125
Chloroethane	ND	250
2-Chloroethylvinylether	ND	250
Chloroform	~~ND~~ 25 (EST)	125
Dichlorobromomethane	ND	125
1,1-Dichloroethane	ND	125
1,2-Dichloroethane	ND	125
1,1-Dichloroethene	2600	125
1,2-Dichloropropane	ND	125
Ethylbenzene	ND	125
Methyl Bromide	ND	250
Methyl Chloride	ND	250
Methylene Chloride	~~ND~~ 13.4	125
1,1,2,2-Tetrachloroethane	ND	125
Tetrachloroethene	ND	125

ND: Not Detected
NA: Not Analyzed

Approved by DeAnne Bryant

APPROVED
JAN 3 1 1992

NOTE. Methylene Chloride in Method Blk = 23 ug/L

Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Lab Number:	LB0177
Sample I.D.:	WCC-8S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS (continued):		
Toluene	~~ND~~ 120 (EST)	125
1,1,1-Trichloroethane	400	125
1,1,2-Trichloroethane	ND	125
Trichloroethene	3000	125
Vinyl Chloride	ND	250
trans-1,3-Dichloropropene	ND	125
cis-1,3-Dichloropropene	ND	125
trans-1,2-Dichloroethene	ND } 40 (EST)	125
cis-1,2-Dichloroethene total	ND	125
Trichlorofluoromethane	ND	250
m,p-Xylenes	ND	125
1,2-Dichlorobenzene	ND	125
1,3-Dichlorobenzene	ND	125
1,4-Dichlorobenzene	ND	125
HAZARDOUS SUBSTANCES COMPOUNDS:		
Acetone	ND	250
2-Butanone	ND	250
Carbon disulfide	ND	125
2-Hexanone	ND	250
4-Methyl-2-Pentanone	ND	250
Styrene	ND	125
Tetrahydrofuran	NA	
Vinyl Acetate	ND	250
o-Xylene	ND	125

ND: Not Detected
NA: Not Analyzed

Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Lab Number:	LB0177
Sample I.D.:	WCC-8S

Compound	Recovery (%)	QC Limits (%)
SURROGATE:		
4-Bromofluorobenzene	105	92-113
1,2-Dichloroethane-d4	110	92-133
Toluene-d8	105	89-114

Note: Results for this sample were submitted to Montgomery Laboratories by Core Laboratories.

ND: Not Detected
NA: Not Analyzed

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Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Douglas Aircraft Co.
**
**
**, ** **
Attn: Majid Rasouli

Job#: 1220.0090
PO#:
Workorder#: W38864
Report#: R85290
Phone #: 6948

ate Sampled: 11/19/91
ate Analyzed: 11/27/91
Date Received: 11/19/91

ab Number: LB0617
ample I.D.: WCC-9S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
OLATILE PRIORITY POLLUTANTS:		
crolein	ND	50
crylonitrile	ND	20
Benzene	ND	1.0
romoform	ND	5.0
arbon Tetrachloride	ND	5.0
Chlorobenzene	ND	5.0
Dibromochloromethane	ND	5.0
hloroethane	ND	10
-Chloroethylvinylether	ND	10
Chloroform	ND	5.0
ichlorobromomethane	ND	5.0
,1-Dichloroethane	ND	5.0
1,2-Dichloroethane	ND	5.0
,1-Dichloroethene	ND	5.0
,2-Dichloropropane	ND	5.0
Ethylbenzene	ND	5.0
Methyl Bromide	ND	10
ethyl Chloride	ND	10
ethylene Chloride	20	5.0
1,1,2,2-Tetrachloroethane	ND	5.0
etrachloroethene	ND	5.0

ND: Not Detected
NA: Not Analyzed

Approved by [illegible]

APPROVED
DEC 10 1991

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number: LB0617
Sample I.D.: WCC-9S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS (continued):		
Toluene	ND	5.0
1,1,1-Trichloroethane	ND	5.0
1,1,2-Trichloroethane	ND	5.0
Trichloroethene	20	5.0
Vinyl Chloride	ND	10
trans-1,3-Dichloropropene	ND	5.0
cis-1,3-Dichloropropene	ND	5.0
trans-1,2-Dichloroethene	ND	5.0
cis-1,2-Dichloroethene	ND	5.0
Trichlorofluoromethane	ND	5.0
Total Xylenes	ND	5.0
1,2-Dichlorobenzene	ND	5.0
1,3-Dichlorobenzene	ND	5.0
1,4-Dichlorobenzene	ND	5.0
HAZARDOUS SUBSTANCES COMPOUNDS:		
Acetone	ND	10
2-Butanone	ND	10
Carbon disulfide	ND	5.0
2-Hexanone	ND	10
4-Methyl-2-Pentanone	ND	10
Styrene	ND	5.0
Vinyl Acetate	ND	10

ND: Not Detected
NA: Not Analyzed

Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Lab Number: LB0617
ˉample I.D.: WCC-9S

ɔmpound	Recovery (%)	QC Limits (%)
JRROGATE:		
4-Bromofluorobenzene	98	92-113
ˑ,2-Dichloroethane-d4	102	92-133
ɔluene-d8	101	89-114

ᴺɔte: Results for this sample were submitted to Montgomery Laboratories by Core Laboratories.

ND: Not Detected
NA: Not Analyzed

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Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Douglas Aircraft Co.		Job#:	1220.0090
**		PO#:	
**		Workorder#:	W38883
**, ** **		Report#:	R85356
Attn: Majid Rasouli		Phone #:	6948

Date Sampled:	11/20/91	Date Received:	11/20/91
Date Analyzed:	11/27/91		

Lab Number:	LB0712
Sample I.D.:	WCC-10-S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS:		
Acrolein	ND	25
Acrylonitrile	ND	25
Benzene	ND	12.5
Bromoform	ND	12.5
Carbon Tetrachloride	ND	12.5
Chlorobenzene	ND	12.5
Dibromochloromethane	ND	12.5
Chloroethane	ND	25
2-Chloroethylvinylether	ND	25
Chloroform	ND	12.5
Dichlorobromomethane	ND	12.5
1,1-Dichloroethane	ND	12.5
1,2-Dichloroethane	ND	12.5
1,1-Dichloroethene	ND	12.5
1,2-Dichloropropane	ND	12.5
Ethylbenzene	ND	12.5
Methyl Bromide	ND	25
Methyl Chloride	ND	25
Methylene Chloride	ND	75
1,1,2,2-Tetrachloroethane	ND	12.5
Tetrachloroethene	ND	12.5

ND: Not Detected
NA: Not Analyzed

Approved by RE Olso

APPROVED
DEC 04 1991

Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Lab Number: LB0712
ample I.D.: WCC-10-S

ompound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
OLATILE PRIORITY POLLUTANTS (continued):		
Toluene	ND	12.5
,1,1-Trichloroethane	ND	12.5
,1,2-Trichloroethane	ND	12.5
Trichloroethene	87	12.5
Vinyl Chloride	ND	25
rans-1,3-Dichloropropene	ND	12.5
is-1,3-Dichloropropene	ND	12.5
trans-1,2-Dichloroethene	ND	12.5
is-1,2-Dichloroethene	ND	12.5
richlorofluoromethane	ND	25
m,p-Xylenes	ND	12.5
,2-Dichlorobenzene	ND	12.5
,3-Dichlorobenzene	ND	12.5
,4-Dichlorobenzene	ND	12.5
AZARDOUS SUBSTANCES COMPOUNDS:		
Acetone	ND	250
-Butanone	ND	25
arbon disulfide	ND	12.5
2-Hexanone	ND	25
-Methyl-2-Pentanone	ND	25
tyrene	ND	12.5
etrahydrofuran	ND	250
Vinyl Acetate	ND	125
-Xylene	ND	12.5

): Not Detected
NA: Not Analyzed

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number:	LB0712
ample I.D.:	WCC-10-S

ompound	Recovery (%)	QC Limits (%)
JRROGATE:		
4-Bromofluorobenzene	102	86-115
,2-Dichloroethane-d4	96	76-114
oluene-d8	100	88-110

): Not Detected
NA: Not Analyzed

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Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Douglas Aircraft Co.		Job#:	1220.0090
**		PO#:	
**		Workorder#:	W38807
**, ** **		Report#:	R84820
Attn:	Majid Rasouli	Phone #:	6948

ate Sampled:	11/15/91	Date Received:	11/15/91
ate Analyzed:	11/27/91		

ab Number:	LB0176
ample I.D.:	WCC-11S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
OLATILE PRIORITY POLLUTANTS:		
crolein	ND	50
crylonitrile	ND	20
Benzene	ND	1.0
romoform	ND	5.0
arbon Tetrachloride	ND	5.0
Chlorobenzene	ND	5.0
ibromochloromethane	ND	5.0
hloroethane	ND	10
-Chloroethylvinylether	ND	10
Chloroform	ND	5.0
ichlorobromomethane	ND	5.0
,1-Dichloroethane	ND	5.0
1,2-Dichloroethane	ND	5.0
,1-Dichloroethene	10	5.0
,2-Dichloropropane	ND	5.0
Ethylbenzene	ND	5.0
Methyl Bromide	ND	10
ethyl Chloride	ND	10
ethylene Chloride	40	5.0
1,1,2,2-Tetrachloroethane	ND	5.0
etrachloroethene	ND	5.0

ND: Not Detected
A: Not Analyzed

Approved by RE Olson

APPROVED
DEC 10 1991

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number:	LB0176
Sample I.D.:	WCC-11S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS (continued):		
Toluene	ND	5.0
1,1,1-Trichloroethane	ND	5.0
1,1,2-Trichloroethane	ND	5.0
Trichloroethene	80	5.0
Vinyl Chloride	ND	10
trans-1,3-Dichloropropene	ND	5.0
cis-1,3-Dichloropropene	ND	5.0
trans-1,2-Dichloroethene	ND	5.0
cis-1,2-Dichloroethene	ND	5.0
Trichlorofluoromethane	ND	5.0
Total Xylenes	ND	5.0
1,2-Dichlorobenzene	ND	5.0
1,3-Dichlorobenzene	ND	5.0
1,4-Dichlorobenzene	ND	5.0
HAZARDOUS SUBSTANCES COMPOUNDS:		
Acetone	ND	10
2-Butanone	ND	10
Carbon disulfide	ND	5.0
2-Hexanone	ND	10
4-Methyl-2-Pentanone	ND	10
Styrene	ND	5.0
Vinyl Acetate	ND	10

ND: Not Detected
NA: Not Analyzed

Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Lab Number:	LB0176
ample I.D.:	WCC-11S

ompound	Recovery (%)	QC Limits (%)
JRROGATE:		
4-Bromofluorobenzene	98	92-113
.2-Dichloroethane-d4	98	92-133
oluene-d8	104	89-114

Note: Reuslts of this sample were submitted to Montgomery Laboratories by Core Laboratories.

ND: Not Detected
NA: Not Analyzed

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Revised Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Douglas Aircraft Co.
**
**
**, ** **
Attn: Majid Rasouli

Job#: 1220.0090
PO#:
Workorder#: W38830
Report#: R85076
Phone #: 6948

Date Sampled: 11/18/91
Date Analyzed: 11/26/91
Date Received: 11/18/91

Lab Number: LB0349
Sample I.D.: WCC-12S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS:		
Acrolein	ND	500
Acrylonitrile	ND	200
Benzene	ND	10
Bromoform	ND	50
Carbon Tetrachloride	ND	50
Chlorobenzene	ND	50
Dibromochloromethane	ND	50
Chloroethane	ND	100
2-Chloroethylvinylether	ND	100
Chloroform	ND	50
Dichlorobromomethane	ND	50
1,1-Dichloroethane	ND	50
1,2-Dichloroethane	ND	50
1,1-Dichloroethene	300	50
1,2-Dichloropropane	ND	50
Ethylbenzene	ND	50
Methyl Bromide	ND	100
Methyl Chloride	ND	100
Methylene Chloride	~~ND~~ 13.6	50
1,1,2,2-Tetrachloroethane	ND	50
Tetrachloroethene	ND	50

ND: Not Detected
NA: Not Analyzed

Approved by DeeAnne Bryant

APPROVED
JAN 31 1992

NOTE: Methylene Chloride in Method Blk = 23 ug/L

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number: LB0349
Sample I.D.: WCC-12S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS (continued):		
Toluene	ND	50
1,1,1-Trichloroethane	~~ND~~ 17 (EST)	50
1,1,2-Trichloroethane	ND	50
Trichloroethene	900	50
Vinyl Chloride	ND	100
trans-1,3-Dichloropropene	ND	50
cis-1,3-Dichloropropene	ND	50
trans-1,2-Dichloroethene	ND	50
cis-1,2-Dichloroethene	ND	50
Trichlorofluoromethane	ND	50
Total Xylenes	ND	50
1,2-Dichlorobenzene	ND	50
1,3-Dichlorobenzene	ND	50
1,4-Dichlorobenzene	ND	50
HAZARDOUS SUBSTANCES COMPOUNDS:		
Acetone	ND	100
2-Butanone	ND	100
Carbon disulfide	ND	50
2-Hexanone	ND	100
4-Methyl-2-Pentanone	ND	100
Styrene	ND	50
Vinyl Acetate	ND	100

ND: Not Detected
NA: Not Analyzed

Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Lab Number:	LB0349
Sample I.D.:	WCC-12S

Compound	Recovery (%)	QC Limits (%)
SURROGATE:		
4-Bromofluorobenzene	107	92-113
1,2-Dichloroethane-d4	111	92-133
Toluene-d8	106	89-114

Note: Reuslts for this sample were submitted to Montgomery Laboratories by Core Laboratories.

ND: Not Detected
NA: Not Analyzed

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Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Douglas Aircraft Co.		Job#:	1220.0090
**		PO#:	
**		Workorder#:	W38807
**, ** **		Report#:	R84817
Attn: Majid Rasouli		Phone #:	6948

Date Sampled: 11/15/91 Date Received: 11/15/91
Date Analyzed: 11/27/91

Lab Number: LB0175
Sample I.D.: WCC-1-D

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS:		
Acrolein	ND	50
Acrylonitrile	ND	20
Benzene	ND	1.0
Bromoform	ND	5.0
Carbon Tetrachloride	ND	5.0
Chlorobenzene	ND	5.0
Dibromochloromethane	ND	5.0
Chloroethane	ND	10
2-Chloroethylvinylether	ND	10
Chloroform	ND	5.0
Dichlorobromomethane	ND	5.0
1,1-Dichloroethane	ND	5.0
1,2-Dichloroethane	ND	5.0
1,1-Dichloroethene	90	5.0
1,2-Dichloropropane	ND	5.0
Ethylbenzene	ND	5.0
Methyl Bromide	ND	10
Methyl Chloride	ND	10
Methylene Chloride	15	5.0
1,1,2,2-Tetrachloroethane	ND	5.0
Tetrachloroethene	ND	5.0

ND: Not Detected
NA: Not Analyzed

Approved by RE Olso

APPROVED
DEC 10 1991

Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Lab Number:	LB0175
Sample I.D.:	WCC-1-D

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS (continued):		
Toluene	20	5.0
1,1,1-Trichloroethane	8.0	5.0
1,1,2-Trichloroethane	ND	5.0
Trichloroethene	40	5.0
Vinyl Chloride	ND	10
trans-1,3-Dichloropropene	ND	5.0
cis-1,3-Dichloropropene	ND	5.0
trans-1,2-Dichloroethene	ND	5.0
cis-1,2-Dichloroethene	ND	5.0
Trichlorofluoromethane	ND	5.0
Total Xylenes	ND	5.0
1,2-Dichlorobenzene	ND	5.0
1,3-Dichlorobenzene	ND	5.0
1,4-Dichlorobenzene	ND	5.0
HAZARDOUS SUBSTANCES COMPOUNDS:		
Acetone	ND	10
2-Butanone	ND	10
Carbon disulfide	ND	5.0
2-Hexanone	ND	10
4-Methyl-2-Pentanone	ND	10
Styrene	ND	5.0
Vinyl Acetate	ND	10

ND: Not Detected
NA: Not Analyzed

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number:	LB0175
Sample I.D.:	WCC-1-D

Compound	Recovery (%)	QC Limits (%)
SURROGATE:		
4-Bromofluorobenzene	104	92-113
1,2-Dichloroethane-d4	99	92-133
Toluene-d8	105	89-114

Note: Results of this sample were submitted to Montgomery Laboratories by Core Laboratories.

ND: Not Detected
NA: Not Analyzed

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Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Douglas Aircraft Co.		Job#:	1220.0090
**		PO#:	
**		Workorder#:	W38776
**, ** **		Report#:	R84583
Attn:	Majid Rasouli	Phone #:	6948

Date Sampled:	11/14/91	Date Received:	11/14/91
Date Analyzed:	11/27/91		

Lab Number:	LB0015
Sample I.D.:	WCC-3D

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS:		
Acrolein	ND	50
Acrylonitrile	ND	20
Benzene	ND	1.0
Bromoform	ND	5.0
Carbon Tetrachloride	ND	5.0
Chlorobenzene	ND	5.0
Dibromochloromethane	ND	5.0
Chloroethane	ND	10
2-Chloroethylvinylether	ND	10
Chloroform	ND	5.0
Dichlorobromomethane	ND	5.0
1,1-Dichloroethane	ND	5.0
1,2-Dichloroethane	ND	5.0
1,1-Dichloroethene	20	5.0
1,2-Dichloropropane	ND	5.0
Ethylbenzene	ND	5.0
Methyl Bromide	ND	10
Methyl Chloride	ND	10
Methylene Chloride	ND	5.0
1,1,2,2-Tetrachloroethane	ND	5.0
Tetrachloroethene	ND	5.0

ND: Not Detected
NA: Not Analyzed

Approved by RE Olson

APPROVED
DEC 10 1991

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number: LB0015
Sample I.D.: WCC-3D

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS (continued):		
Toluene	ND	5.0
1,1,1-Trichloroethane	60	5.0
1,1,2-Trichloroethane	ND	5.0
Trichloroethene	ND	5.0
Vinyl Chloride	ND	10
trans-1,3-Dichloropropene	ND	5.0
cis-1,3-Dichloropropene	ND	5.0
trans-1,2-Dichloroethene	ND	5.0
cis-1,2-Dichloroethene	ND	5.0
Trichlorofluoromethane	ND	5.0
Total Xylenes	ND	5.0
1,2-Dichlorobenzene	ND	5.0
1,3-Dichlorobenzene	ND	5.0
1,4-Dichlorobenzene	ND	5.0
HAZARDOUS SUBSTANCES COMPOUNDS:		
Acetone	ND	10
2-Butanone	ND	10
Carbon disulfide	ND	5.0
2-Hexanone	ND	10
4-Methyl-2-Pentanone	ND	10
Styrene	ND	5.0
Vinyl Acetate	ND	10

ND: Not Detected
NA: Not Analyzed

Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Lab Number:	LB0015
Sample I.D.:	WCC-3D

Compound	Recovery (%)	QC Limits (%)
SURROGATE:		
4-Bromofluorobenzene	104	92-113
1,2-Dichloroethane-d4	99	92-133
Toluene-d8	105	89-114

Note: Results for this sample were submitted to Montgomery Laboratories by Core Laboratories.

ND: Not Detected
NA: Not Analyzed

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Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Douglas Aircraft Co.
**
**
**, ** **
Attn: Majid Rasouli

MONTGOMERY CONSULTING ENGINEERS, INC.
Job#: 1220.0090
PO#:
Workorder#: W38883
Report#: R85357
Phone #: 6948

ate Sampled: 11/20/91
ate Analyzed: 11/27/91
Date Received: 11/20/91

ab Number: LB0713
ample I.D.: DAC-P1

Compound	Concentration (milligrams/liter)	Detection Limit (milligrams/liter)
OLATILE PRIORITY POLLUTANTS:		
crolein	ND	10
crylonitrile	ND	10
Benzene	ND	5.0
romoform	ND	5.0
arbon Tetrachloride	ND	5.0
Chlorobenzene	ND	5.0
Dibromochloromethane	ND	5.0
hloroethane	ND	10
-Chloroethylvinylether	ND	10
Chloroform	ND	5.0
ichlorobromomethane	ND	5.0
,1-Dichloroethane	ND	5.0
1,2-Dichloroethane	ND	5.0
1,1-Dichloroethene	ND	5.0
,2-Dichloropropane	ND	5.0
Ethylbenzene	ND	5.0
Methyl Bromide	ND	10
ethyl Chloride	ND	10
ethylene Chloride	ND	30
1,1,2,2-Tetrachloroethane	ND	5.0
etrachloroethene	ND	5.0

ND: Not Detected
NA: Not Analyzed

Approved by RE Olson

APPROVED
DEC 0 4 1991

Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Lab Number:	LB0713
Sample I.D.:	DAC-P1

Compound	Concentration (milligrams/liter)	Detection Limit (milligrams/liter)
VOLATILE PRIORITY POLLUTANTS (continued):		
Toluene	ND	5.0
1,1,1-Trichloroethane	ND	5.0
1,1,2-Trichloroethane	ND	5.0
Trichloroethene	43	5.0
Vinyl Chloride	ND	10
trans-1,3-Dichloropropene	ND	5.0
cis-1,3-Dichloropropene	ND	5.0
trans-1,2-Dichloroethene	ND	5.0
cis-1,2-Dichloroethene	ND	5.0
Trichlorofluoromethane	ND	10
m,p-Xylenes	ND	5.0
1,2-Dichlorobenzene	ND	5.0
1,3-Dichlorobenzene	ND	5.0
1,4-Dichlorobenzene	ND	5.0
HAZARDOUS SUBSTANCES COMPOUNDS:		
Acetone	ND	100
2-Butanone	ND	10
Carbon disulfide	ND	5.0
2-Hexanone	ND	10
4-Methyl-2-Pentanone	ND	10
Styrene	ND	5.0
Tetrahydrofuran	ND	100
Vinyl Acetate	ND	50
o-Xylene	ND	5.0

ND: Not Detected
NA: Not Analyzed

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number: LB0713
'ample I.D.: DAC-P1

ompound	Recovery (%)	QC Limits (%)
JRROGATE:		
4-Bromofluorobenzene	101	86-115
,2-Dichloroethane-d4	99	76-114
oluene-d8	99	88-110

Note: Results of this sample were given in milligrams/liter instead of micrograms/liter due to high concentration of trichloroethene in the sample.

ND: Not Detected
A: Not Analyzed

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Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Douglas Aircraft Co.
**
**
**, ** **
Attn: Majid Rasouli

Job#: 1220.0090
PO#:
Workorder#: W38864
Report#: R85295
Phone #: 6948

Date Sampled: 11/19/91
Date Analyzed: 11/27/91
Date Received: 11/19/91

Lab Number: LB0621
Sample I.D.: TB-1 11/19/91

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS:		
Acrolein	ND	50
Acrylonitrile	ND	20
Benzene	ND	1.0
Bromoform	ND	5.0
Carbon Tetrachloride	ND	5.0
Chlorobenzene	ND	5.0
Dibromochloromethane	ND	5.0
Chloroethane	ND	10
2-Chloroethylvinylether	ND	10
Chloroform	ND	5.0
Dichlorobromomethane	ND	5.0
1,1-Dichloroethane	ND	5.0
1,2-Dichloroethane	ND	5.0
1,1-Dichloroethene	ND	5.0
1,2-Dichloropropane	ND	5.0
Ethylbenzene	ND	5.0
Methyl Bromide	ND	10
Methyl Chloride	ND	10
Methylene Chloride	30	5.0
1,1,2,2-Tetrachloroethane	ND	5.0
Tetrachloroethene	ND	5.0

ND: Not Detected
NA: Not Analyzed

Approved by RE Olson

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Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number:	LB0621
ample I.D.:	TB-1 11/19/91

ompound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
OLATILE PRIORITY POLLUTANTS (continued):		
Toluene	ND	5.0
,1,1-Trichloroethane	ND	5.0
,1,2-Trichloroethane	ND	5.0
Trichloroethene	ND	5.0
Vinyl Chloride	ND	10
rans-1,3-Dichloropropene	ND	5.0
cis-1,3-Dichloropropene	ND	5.0
trans-1,2-Dichloroethene	ND	5.0
is-1,2-Dichloroethene	ND	5.0
richlorofluoromethane	ND	5.0
Total Xylenes	ND	5.0
1,2-Dichlorobenzene	ND	5.0
,3-Dichlorobenzene	ND	5.0
,4-Dichlorobenzene	ND	5.0
AZARDOUS SUBSTANCES COMPOUNDS:		
Acetone	ND	10
-Butanone	ND	10
arbon disulfide	ND	5.0
2-Hexanone	ND	10
4-Methyl-2-Pentanone	ND	10
tyrene	ND	5.0
Vinyl Acetate	ND	10

ND: Not Detected
NA: Not Analyzed

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number: LB0621
S mple I.D.: TB-1 11/19/91

C mpound	Recovery (%)	QC Limits (%)
S RROGATE:		
4-Bromofluorobenzene	95	92-113
? 2-Dichloroethane-d4	101	92-133
T luene-d8	102	89-114

Note: Results for this sample were submitted to Montgomery Laboratories by Core Laboratories.

ND: Not Detected
NA: Not Analyzed

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Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Douglas Aircraft Co.		Job#:	1220.0090
**		PO#:	
**		Workorder#:	W38883
**, ** **		Report#:	R85358
Attn: Majid Rasouli		Phone #:	6948

ate Sampled: 11/20/91 Date Received: 11/20/91
ate Analyzed: 11/27/91

ab Number: LB0714
ample I.D.: DAC-TB-2

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
OLATILE PRIORITY POLLUTANTS:		
crolein	ND	5.0
crylonitrile	ND	5.0
Benzene	ND	2.5
romoform	ND	2.5
arbon Tetrachloride	ND	2.5
Chlorobenzene	ND	2.5
Dibromochloromethane	ND	2.5
hloroethane	ND	5.0
-Chloroethylvinylether	ND	5.0
Chloroform	ND	2.5
ichlorobromomethane	ND	2.5
,1-Dichloroethane	ND	2.5
1,2-Dichloroethane	ND	2.5
,1-Dichloroethene	ND	2.5
2-Dichloropropane	ND	2.5
Ethylbenzene	ND	2.5
Methyl Bromide	ND	5.0
ethyl Chloride	ND	5.0
ethylene Chloride	34	15
1,1,2,2-Tetrachloroethane	ND	2.5
etrachloroethene	ND	2.5

ND: Not Detected
NA: Not Analyzed

Approved by RE Olson

APPROVED
DEC 0 5 1991

Report of GC/MS Analysis for VOLATILE ORGANICS in Water

Lab Number: LB0714
Sample I.D.: DAC-TB-2

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
VOLATILE PRIORITY POLLUTANTS (continued):		
Toluene	ND	2.5
1,1,1-Trichloroethane	ND	2.5
1,1,2-Trichloroethane	ND	2.5
Trichloroethene	2.5	2.5
Vinyl Chloride	ND	5.0
trans-1,3-Dichloropropene	ND	2.5
cis-1,3-Dichloropropene	ND	2.5
trans-1,2-Dichloroethene	ND	2.5
cis-1,2-Dichloroethene	ND	2.5
Trichlorofluoromethane	ND	5.0
m,p-Xylenes	ND	2.5
1,2-Dichlorobenzene	ND	2.5
1,3-Dichlorobenzene	ND	2.5
1,4-Dichlorobenzene	ND	2.5
HAZARDOUS SUBSTANCES COMPOUNDS:		
Acetone	ND	50
2-Butanone	ND	5.0
Carbon disulfide	ND	2.5
2-Hexanone	ND	5.0
4-Methyl-2-Pentanone	ND	5.0
Styrene	ND	2.5
Tetrahydrofuran	ND	50
Vinyl Acetate	ND	25
o-Xylene	ND	2.5

ND: Not Detected
NA: Not Analyzed

Report of GC/MS Analysis for
VOLATILE ORGANICS
in Water

Lab Number: LB0714
ample I.D.: DAC-TB-2

ompound	Recovery (%)	QC Limits (%)
URROGATE:		
4-Bromofluorobenzene	101	86-115
,2-Dichloroethane-d4	99	76-114
oluene-d8	100	88-110

ote: Methylene chloride and trichloroethene were not detected in the associated stationary blank.
None of the target analytes was detected in the method blank analyzed immediately before this travel blank.

D: Not Detected
NA: Not Analyzed

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Report of General Mineral Analysis

Douglas Aircraft Co.
**
**
**, ** **
Attn: Majid Rasouli

Job#: 1220.0090
PO#:
Workorder#: W38776
Report#: R84580
Phone #: 6948

Date Sampled: 11/14/91
Date Completed: 12/11/91
Date Received: 11/14/91

Sample Lab Number: LB0014 Sample ID: WCC-3S

CATIONS:	(mg/l)	(meq/l)	ANIONS:	(mg/l)	(meq/l)
			Bicarbonate	396	6.48
Sodium	90	3.91	Carbonate	0.48	0.02
Potassium	5.2	0.13	Chloride	300	8.45
Calcium	115	5.75	Sulfate	42	0.88
Magnesium	38	3.17	Nitrate-N	<0.3	ND
			Fluoride	0.19	0.01
			Hydroxide	0.00	0.00

CATION SUM = 13.0 meq/l ANION SUM = 15.8 meq/l

OTHER WATER QUALITY PARAMETERS DETERMINED (mg/l):

pH (unitless)	7.2	Copper	0.018
Conductance (umho/cm)	1460	Iron	5.3
Alkalinity	325	Manganese	1.9
TDS	820	Surfactants	<0.05
Hardness	446	Zinc	0.095
Langelier Index	0.2	Aluminum	2.8
pH of CaCO3 saturation (25C)	7.0		
pH of CaCO3 saturation (60C)	6.5		
Free CO2 (25C)	50.		

NA: Not Analyzed ND: Not Detected

Approved by RE Olson

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Report of General Mineral Analysis

Douglas Aircraft Co.
**
**
**, ** **
Attn: Majid Rasouli

Job#: 1220.0090
PO#:
Workorder#: W38830
Report#: R85072
Phone #: 6948

Date Sampled: 11/18/91
Date Completed: 12/26/91
Date Received: 11/18/91

Sample Lab Number: LB0348 Sample ID: WCC-7S

CATIONS:	(mg/l)	(meq/l)	ANIONS:	(mg/l)	(meq/l)
			Bicarbonate	146	2.39
Sodium	78	3.39	Carbonate	0.42	0.01
Potassium	6.9	0.18	Chloride	215	6.06
Calcium	81	4.05	Sulfate	20	0.42
Magnesium	24	2.00	Nitrate-N	1.9	0.14
			Fluoride	0.24	0.01
			Hydroxide	0.00	0.00

CATION SUM = 9.62 meq/l ANION SUM = 9.03 meq/l

OTHER WATER QUALITY PARAMETERS DETERMINED (mg/l):

pH (unitless)	7.6	Copper	0.019
Conductance (umho/cm)	1120	Iron	1.7
Alkalinity	120	Manganese	0.041
TDS	650	Surfactants	<0.05
Hardness	303	Zinc	0.021
Langelier Index	0.1	Aluminum	2.1
pH of CaCO3 saturation (25C)	7.5		
pH of CaCO3 saturation (60C)	7.0		
Free CO2 (25C)	7.3		

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CONSULTING ENGINEERS, INC.

NA: Not Analyzed ND: Not Detected

Approved by RE Olson

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DEC 27 1991

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Report of General Mineral Analysis

Douglas Aircraft Co.
**
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**, ** **
Attn: Majid Rasouli

Job#: 1220.0090
PO#:
Workorder#: W38807
Report#: R84819
Phone #: 6948

Date Sampled: 11/15/91
Date Completed: 12/20/91
Date Received: 11/15/91

Sample Lab Number: LB0175 Sample ID: WCC-1-D

CATIONS:	(mg/l)	(meq/l)	ANIONS:	(mg/l)	(meq/l)
			Bicarbonate	230	3.78
Sodium	55	2.39	Carbonate	0.77	0.03
Potassium	4.0	0.10	Chloride	92	2.59
Calcium	53	2.65	Sulfate	33	0.69
Magnesium	15	1.25	Nitrate-N	<0.2	ND
			Fluoride	0.33	0.02
			Hydroxide	0.00	0.00

CATION SUM = 6.39 meq/l ANION SUM = 7.1 meq/l

OTHER WATER QUALITY PARAMETERS DETERMINED (mg/l):

pH (unitless)	7.7	Copper	0.014
Conductance (umho/cm)	705	Iron	0.57
Alkalinity	190	Manganese	0.077
TDS	400	Surfactants	<0.05
Hardness	195	Zinc	0.039
Langelier Index	0.2	Aluminum	1.5
pH of CaCO3 saturation (25C)	7.5		
pH of CaCO3 saturation (60C)	7.0		
Free CO2 (25C)	9.2		

NA: Not Analyzed ND: Not Detected

Approved by REdlson

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Report of Inorganic Analyses

Douglas Aircraft Co.
**
**
**, ** **
Attn: Majid Rasouli

Job#: 1220.0090
PO#:
Workorder#: W38776
Report#: R84577
Phone #: 6948

I te Sampled: 11/14/91
Date Completed: 12/9/91
Date Received: 11/14/91

Lab#	Sample I.D.	COD mg/l
LB0014	WCC-3S	290

NA: Not Analyzed

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Report of Inorganic Analyses

Douglas Aircraft Co.
**
**
**, ** **
Attn: Majid Rasouli

Job#: 1220.0090
PO#:
Workorder#: W38830
Report#: R85069
Phone #: 6948

ate Sampled: 11/18/91
Date Received: 11/18/91
Date Completed: 12/9/91

Lab#	Sample I.D.	COD mg/l
LB0348	WCC-7S	56

NA: Not Analyzed

Approved by RE Olson

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Report of Inorganic Analyses

Douglas Aircraft Co.
**
**
**, ** **
Attn: Majid Rasouli

Job#: 1220.0090
PO#:
Workorder#: W38864
Report#: R85289
Phone #: 6948

ate Sampled: 11/19/91
Date Completed: 12/9/91
Date Received: 11/19/91

Lab#	Sample I.D.	COD mg/l
LB0617	WCC-9S	20

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Report of Inorganic Analyses

Douglas Aircraft Co.
**
**
**, ** **
Attn: Majid Rasouli

Job#: 1220.0090
PO#:
Workorder#: W38807
Report#: R84816
Phone #: 6948

I te Sampled: 11/15/91
Date Completed: 12/9/91
Date Received: 11/15/91

Lab#	Sample I.D.	COD mg/l
LB0175	WCC-1-D	10

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DEC 1 6 1991

NA: Not Analyzed

Approved by REOlso

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Report of Analysis for
TOTAL ORGANIC CARBON

Douglas Aircraft Co.
**
**
**, ** **
Attn: Majid Rasouli

Job#: 1220.0090
PO#:
Workorder#: W38830
Report#: R85071
Phone #: 6948

Date Sampled: 11/18/91
Date Analyzed: 11/19/91
Date Received: 11/18/91

Lab#	Sample Description	Total Organic Carbon (milligrams/liter)
LB0348	WCC-7S	0.7

NA: Not analyzed
ND: Not detected
Minimum detection limit = 0.5 milligrams/liter

Approved by RE Olson

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Report of Analysis for TOTAL ORGANIC CARBON

Douglas Aircraft Co.	Job#: 1220.0090
**	PO#:
**	Workorder#: W38864
**, ** **	Report#: R85291
Attn: Majid Rasouli	Phone #: 6948

Date Sampled: 11/19/91 Date Received: 11/19/91
ate Analyzed: 11/22/91

ab#	Sample Description	Total Organic Carbon (milligrams/liter)
30617	WCC-9S	0.9

\: Not analyzed
): Not detected
Minimum detection limit = 0.5 milligrams/liter

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Report of Analysis for
TOTAL ORGANIC CARBON

Douglas Aircraft Co.		Job#:	1220.0090
**		PO#:	
**		Workorder#:	W38807
**, ** **		Report#:	R84818
Attn: Majid Rasouli		Phone #:	6948

Date Sampled:	11/15/91	Date Received:	11/15/91
Date Analyzed:	11/19/91		

Lab#	Sample Description	Total Organic Carbon (milligrams/liter)
LB0175	WCC-1-D	0.7

NA: Not analyzed
ND: Not detected
Minimum detection limit = 0.5 milligrams/liter

Approved by REOlson

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Report of CAM Metals in Water

Douglas Aircraft Co.
**
**
**, ** **
Attn: Majid Rasouli

Job#: 1220.0090
PO#:
Workorder#: W38776
Report#: R84581
Phone #: 6948

Date Sampled: 11/14/91
Date Completed: 1/16/92
Date Received: 11/14/91

Lab#	Sample I.D.	Pb mg/l	Cr VI mg/l	Co mg/l	Cr mg/l	Cd mg/l	Be mg/l
LB0014	WCC-3S	0.001	<0.010	<0.050	<0.010	<0.005	<0.005

Lab#	Sample I.D.	Ba mg/l	As mg/l	Sb mg/l	Hg mg/l	Mo mg/l	Ni mg/l
LB0014	WCC-3S	0.24	0.016	<0.050	<0.0002	<0.050	<0.040

Lab#	Sample I.D.	Se mg/l	Ag mg/l	Tl mg/l	V mg/l
LB0014	WCC-3S	<0.005	<0.010	<0.010	<0.050

NA: Not Analyzed

Approved by A Eaton

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Report of CAM Metals in Water

Douglas Aircraft Co.
**
**
**, ** **
Attn: Majid Rasouli

Job#: 1220.0090
PO#:
Workorder#: W38830
Report#: R85073
Phone #: 6948

Date Sampled: 11/18/91
Date Completed: 1/16/92
Date Received: 11/18/91

Lab#	Sample I.D.	Pb mg/l	Cr VI mg/l	Co mg/l	Cr mg/l	Cd mg/l	Be mg/l
LB0348	WCC-7S	0.003	0.010	<0.050	0.018	<0.005	<0.005

Lab#	Sample I.D.	Ba mg/l	As mg/l	Sb mg/l	Hg mg/l	Mo mg/l	Ni mg/l
LB0348	WCC-7S	0.11	<0.005	<0.050	<0.0002	<0.050	<0.040

Lab#	Sample I.D.	Se mg/l	Ag mg/l	Tl mg/l	V mg/l
LB0348	WCC-7S	<0.005	<0.010	<0.010	<0.050

NA: Not Analyzed

Approved by A. Eaton

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JAN 16 1992

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a division of James M. Montgomery, Consulting Engineers, Inc.
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(818) 796-9141 / (213) 681-4255 Telex 67-5420

Report of GC/MS Analysis for BASE/NEUTRAL/ACID EXTRACTABLE ORGANICS in Water

Douglas Aircraft Co.
**
**
**, ** **
Attn: Majid Rasouli

Job#: 1220.0090
PO#:
Workorder#: W38776
Report#: R84579
Phone #: 6948

ˉate Sampled: 11/14/91
ate Extracted: 11/18/91
Date Received: 11/14/91
Date Analyzed: 11/29/91

ab Number: LB0014
ample I.D.: WCC-3S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
ASE/NEUTRAL EXTRACTABLE-PRIORITY POLLUTANTS:		
cenaphthene	ND	12.5
Acenaphthylene	ND	12.5
nthracene	ND	12.5
enzidine	ND	125
Benzo(a)anthracene	ND	12.5
Benzo(a)pyrene	ND	12.5
enzo(g,h,i)perylene	ND	25
benzo(b)fluoranthene	ND	12.5
Benzo(k)fluoranthene	ND	12.5
is(2-Chloroethoxy)methane	ND	25
is(2-Choroethyl)ether	ND	25
bis(2-Chloroisopropyl)ether	ND	25
is(2-Ethylhexyl)phthalate	ND	50
-Bromophenylphenylether	ND	12.5
Butylbenzylphthalate	ND	12.5
2-Chloronaphthalene	ND	12.5
-Chlorophenylphenylether	ND	12.5
hrysene	ND	12.5
Dibenzo(a,h)anthracene	ND	25
,2-Dichlorobenzene	ND	12.5

ND: Not Detected
ˉA: Not Analyzed

Approved by RE Olson

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PASADENA
JAMES M. MONTGOMERY
CONSULTING ENGINEERS, INC.

APPROVED
DEC 05 1991

Report of GC/MS Analysis for BASE/NEUTRAL/ACID EXTRACTABLE ORGANICS in Water

Lab Number:	LB0014
ample I.D.:	WCC-3S

ompound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
ASE/NEUTRAL EXTRACTABLE- RIORITY POLLUTANTS (continued):		
,3-Dichlorobenzene	ND	12.5
,4-Dichlorobenzene	ND	12.5
3,3'-Dichlorobenzidine	ND	125
Diethylphthalate	ND	12.5
imethylphthalate	ND	12.5
i-n-butylphthalate	ND	25
2,4-Dinitrotoluene	ND	12.5
,6-Dinitrotoluene	ND	12.5
i-n-octylphthalate	ND	25
1,2-Diphenylhydrazine	ND	25
Fluoranthene	ND	12.5
luorene	ND	12.5
Hexachlorobenzene	ND	12.5
Hexachlorobutadiene	ND	25
exachlorocyclopentadiene	ND	25
exachloroethane	ND	12.5
Indeno(1,2,3-c,d)pyrene	ND	25
sophorone	ND	12.5
aphthalene	ND	12.5
Nitrobenzene	ND	12.5
N-Nitrosodimethylamine	ND	12.5
-Nitrosodi-N-propylamine	ND	12.5
N-Nitrosodiphenylamine	ND	12.5
Phenanthrene	ND	12.5
yrene	ND	12.5
,2,4-Trichlorobenzene	ND	12.5
CID EXTRACTABLE PRIORITY POLLUTANTS:		
2-Chlorophenol	ND	12.5
2,4-Dichlorophenol	ND	12.5
,4-Dimethylphenol	ND	12.5
4,6-Dinitro-o-cresol	ND	125
2,4-Dinitrophenol	ND	125
-Nitrophenol	ND	12.5
-Nitrophenol	ND	25

ND: Not Detected
A: Not Analyzed

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Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
ACID EXTRACTABLE PRIORITY POLLUTANTS (continued):		
p-Chloro-m-cresol	ND	12.5
Pentachlorophenol	ND	25
Phenol	ND	12.5
2,4,6-Trichlorophenol	ND	12.5
HAZARDOUS SUBSTANCES COMPOUNDS:		
Aniline	ND	12.5
Benzyl Alcohol	ND	12.5
2-Methylphenol	ND	12.5
4-Methylphenol	ND	12.5
Benzoic Acid	300	125
4-Chloroaniline	ND	12.5
2-Methylnaphthalene	ND	12.5
Dibenzofuran	ND	12.5
2-Nitroaniline	ND	25
3-Nitroaniline	ND	50
4-Nitroaniline	ND	50
2,4,5-Trichlorophenol	ND	12.5

ND: Not Detected
NA: Not Analyzed

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ompound	Recovery (%)	QC Limits (%)
JRROGATE:		
Nitrobenzene-d5	96	35-114
-Fluorobiphenyl	85	43-116
erphenyl-d14	48	33-141
-Fluorophenol	7.6	21-100
Phenol-d5	18	10-94
,4,6-Tribromophenol	13	10-123

): Not Detected
NA: Not Analyzed

MONTGOMERY LABORATORIES
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Report of GC/MS Analysis for
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Douglas Aircraft Co.	Job#: 1220.0090
**	PO#:
**	Workorder#: W38830
**, ** **	Report#: R85074
Attn: Majid Rasouli	Phone #: 6948

Date Sampled:	11/18/91	Date Received:	11/18/91
Date Extracted:	11/20/91	Date Analyzed:	12/9/91

Lab Number: LB0348
Sample I.D.: WCC-7S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
BASE/NEUTRAL EXTRACTABLE- PRIORITY POLLUTANTS:		
Acenaphthene	ND	5.0
Acenaphthylene	ND	5.0
Anthracene	ND	5.0
Benzidine	ND	50
Benzo(a)anthracene	ND	5.0
Benzo(a)pyrene	ND	5.0
Benzo(g,h,i)perylene	ND	10
Benzo(b)fluoranthene	ND	5.0
Benzo(k)fluoranthene	ND	5.0
bis(2-Chloroethoxy)methane	ND	10
bis(2-Choroethyl)ether	ND	10
bis(2-Chloroisopropyl)ether	ND	10
bis(2-Ethylhexyl)phthalate	ND	20
-Bromophenylphenylether	ND	5.0
Butylbenzylphthalate	ND	5.0
2-Chloronaphthalene	ND	5.0
-Chlorophenylphenylether	ND	5.0
Chrysene	ND	5.0
Dibenzo(a,h)anthracene	ND	10
,2-Dichlorobenzene	ND	5.0

ND: Not Detected
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Approved by REWilson

APPROVED
DEC 10 1991

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Lab Number: LB0348
Sample I.D.: WCC-7S

Compound	Concentration (micrograms/liter)	Detection Limit (micrograms/liter)
BASE/NEUTRAL EXTRACTABLE-PRIORITY POLLUTANTS (continued):		
1,3-Dichlorobenzene	ND	5.0
1,4-Dichlorobenzene	ND	5.0
3,3'-Dichlorobenzidine	ND	50
Diethylphthalate	ND	5.0
Dimethylphthalate	ND	5.0
Di-n-butylphthalate	ND	10
2,4-Dinitrotoluene	ND	5.0
2,6-Dinitrotoluene	ND	5.0
Di-n-octylphthalate	ND	10
1,2-Diphenylhydrazine	ND	10
Fluoranthene	ND	5.0
Fluorene	ND	5.0
Hexachlorobenzene	ND	5.0
Hexachlorobutadiene	ND	10
Hexachlorocyclopentadiene	ND	10
Hexachloroethane	ND	5.0
Indeno(1,2,3-c,d)pyrene	ND	10
Isophorone	ND	5.0
Naphthalene	ND	5.0
Nitrobenzene	ND	5.0
N-Nitrosodimethylamine	ND	5.0
N-Nitrosodi-N-propylamine	ND	5.0
N-Nitrosodiphenylamine	ND	5.0
Phenanthrene	ND	5.0
Pyrene	ND	5.0
1,2,4-Trichlorobenzene	ND	5.0
ACID EXTRACTABLE PRIORITY POLLUTANTS:		
2-Chlorophenol	ND	5.0
2.4-Dichlorophenol	ND	5.0
2,4-Dimethylphenol	ND	5.0
4,6-Dinitro-o-cresol	ND	50
2,4-Dinitrophenol	ND	50
2-Nitrophenol	ND	5.0
4-Nitrophenol	ND	10

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ACID EXTRACTABLE PRIORITY POLLUTANTS (continued):		
p-Chloro-m-cresol	ND	5.0
Pentachlorophenol	ND	10
Phenol	ND	5.0
2,4,6-Trichlorophenol	ND	5.0
HAZARDOUS SUBSTANCES COMPOUNDS:		
Aniline	ND	5.0
Benzyl Alcohol	ND	5.0
2-Methylphenol	ND	5.0
4-Methylphenol	ND	5.0
Benzoic Acid	ND	50
4-Chloroaniline	ND	5.0
Methylnaphthalene	ND	5.0
Dibenzofuran	ND	5.0
2-Nitroaniline	ND	10
3-Nitroaniline	ND	20
4-Nitroaniline	ND	20
2,4,5-Trichlorophenol	ND	5.0

: Not Detected
NA: Not Analyzed

Report of GC/MS Analysis for
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Lab Number:	LB0348
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Compound	Recovery (%)	QC Limits (%)
SURROGATE:		
Nitrobenzene-d5	42	35-114
2-Fluorobiphenyl	36	43-116
Terphenyl-d14	52	33-141
2-Fluorophenol	51	21-100
Phenol-d5	50	10-94
2,4,6-Tribromophenol	60	10-123

ND: Not Detected
NA: Not Analyzed